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THE UNIVERSITY OF ALBERTA

# North American Hog Price Relationships

by

Nancy Jean Higginson

(C)

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

IN

Agicultural Economics

Department of Rural Economy

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Fall, 1987

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Date..October 9, 1987.....

## ABSTRACT

Canada and the United States (US) traded freely in swine and fresh and frozen pork products for many years. However, a substantial increase in imports of Canadian swine in 1983 and 1984 caused concern among US producers, and their lobbying efforts culminated in the imposition of a countervailing duty in April 1985.

The objectives of this research were twofold: 1) to determine if Canadian swine exports into US markets over the 1982 to 1985 period had a significant effect on US prices, and 2) to assess the impact of the countervailing duty on pricing efficiency in the Canadian slaughter hog markets.

In markets that are linked through trade relationships, such as the North American hog markets, changes in one market should be readily reflected in the other markets, indicating a high degree of pricing efficiency. Here, pricing efficiency is defined as the rapidity, accuracy and effectiveness with which market information is transmitted through marketing channels. Trade barriers will have a negative impact on pricing efficiency. One would expect the countervailing duty to decrease the pricing efficiency between the US and Canadian hog markets, then.

Several empirical methods have been used to analyze pricing relationships in agricultural markets: structural econometric models, univariate time series models and multivariate time series models. The vector autoregression (VAR) technique, representing a recent development in multivariate modelling, was chosen to analyze the study hypotheses. VAR models have received attention for their ability to evaluate the dynamic interrelationships among three or more time series in one

A. INTRODUCTION .....47

ICE DETERMINATION .....49
Pricing Under Perfect Competition .....50
Pricing Under Oligopoly .....53
ORAL PRICE RELATIONSHIPS .....55
AL PRICE RELATIONSHIPS .....59
NG EFFICIENCY .....61
RY .....65
ANALYTIC TECHNIQUES .....66
RODUCTION .....66
RUCTURAL ECONOMETRIC MODELS .....67
IVARIATE TIME SERIES MODELS .....69
ULTIVARIATE TIME SERIES MODELS .....75
UMMARY .....78
OLOGY .....80
RODUCTION .....80
ROUND NOTES ON VECTOR AUTOREGRESSION .....80
TRICTED VECTOR AUTOREGRESSIONS .....84
ckground .....84
oice Of Lag Length In A VAR .....86
novation Accounting Techniques .....87
thogonal Ordering .....90
mmary .....92
NORTH AMERICAN HOG PRICES .....93
ta .....93
ND INTERPRETATION OF EMPIRICAL ANALYSIS .....96
RODUCTION .....96
B. PRICE DIFFERENTIALS IN HOG MARKETS .....96

W. Canada-E. Canada Price Spreads .....99
Western Canada-US Price Spreads .....99
Eastern Canada-US Price Spreads .....102
C. VAR MODELS .....102
Model Estimation .....102
Innovation Accounting Analysis .....112
D. SUMMARY .....121
VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS .....123
A. REVIEW OF RESEARCH OBJECTIVES .....123
B. SUMMARY OF GRAPHICAL ANALYSIS .....124
Historical Price Movements .....124
Price Differentials .....125
C. SUMMARY OF VAR ANALYSIS .....126
Technical Results .....126
D. CONCLUSIONS .....128
E. RECOMMENDATIONS FOR FUTURE RESEARCH .....131
BIBLIOGRAPHY .....132

## List of Tables


| Table | | Page |
|---|---|---|
| II.1 | Farm Cash Receipts- Canada, 1970 and 1985 | 21 |
| II.2 | Distribution Of Swine Production In Canada - 1981 | 26 |
| II.3 | Types Of Swine Enterprise In Canada - 1981 | 28 |
| V.1 | Variables, Mnemonics And Sources Of Data | 94 |
| VI.1 | Likelihood Ratio Test To Determine Lag Length | 105 |
| VI.2 | Measure Of Fit And Standard Deviation Of Errors- Autoregressive Equations | 107 |
| VI.3 | Ljung-Box Q Test For Serial Correlation | 108 |
| VI.4 | F-Test for Significance Of Lags Of Each Variable, Model I | 110 |
| VI.5 | F-Test For Significance Of Lags Of Each Variable, Model II | 111 |
| VI.6 | Variance Decomposition Of Prediction Errors, Model I | 114 |
| VI.7 | Variance Decomposition Of Prediction Errors, Model II | 115 |
| VI.8 | Changes In Variance Decomposition Between Model I And Model II | 118 |
| VI.9 | Residual Cross Correlations, Model I | 119 |
| VI.10 | Residual Cross Correlations, Model II | 120 |
| VI.11 | Responses To One Standard Deviation Shock In Live Hog Exports On US Prices | 122 |

## List of Figures


| Figure | | Page |
|---|---|---|
| I.1 | Canadian Dollars Expressed as US Dollars, 1970-1986 | 4 |
| I.2 | Total Pork Trade With The US, 1970-1986 | 6 |
| I.3 | Canadian Swine Exports To The US, 1970-1986 | 8 |
| I.4 | Canada's Net Trade Balance With The US, 1970-1986 | 9 |
| II.1 | The US Pork Production And Marketing System | 19 |
| VI.1 | Slaughter Hog Prices In Canada And The US, 1982-1986 | 98 |
| VI.2 | Hog Price Differentials, 1982-1986. W. Canada Minus E. Canada | 100 |
| VI.3 | Hog Price Differentials, 1982-1986. W. Canada Minus US-7 | 101 |
| VI.4 | Hog Price Differentials, 1982-1986. E. Canada Minus US-7 | 103 |

# I. INTRODUCTION

## A. BACKGROUND

Canada and the United States (US) have enjoyed a relatively free trade relationship in swine and fresh or frozen pork products for many years. Pork and pork products, especially, have travelled freely across the border in both directions.

Since 1980 (under the negotiated results of the General Agreement on Tariffs and Trade, Tokyo Round) both countries have enforced a zero bound duty for swine and fresh or frozen pork products.[1] However, non-tariff (economic and health) barriers have frequently been used to restrain trading activity.

The federal Departments of Agriculture in both countries administer health and sanitary regulations to protect their respective livestock industries and ensure an adequate supply of safe meat for consumers. For example, in 1984, 3.3 million pounds of Canadian pork were refused entry to the US on the following grounds: unsound cans, adulteration with extraneous material, short weight, failure to meet composition standards, undercooked, and presence of biological residues.[2]

Canadian imports of swine from the US are subject to regulations contained in the Animal Disease and Protection Act regarding pseudorabies ("mad itch"), a contagious disease present in some swine and cattle herds in the US. Swine imports are permitted only from herds that are certified as disease-free for one year prior, and then they

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[1]United States International Trade Commission. "Live Swine and Pork from Canada." USITC Publication 1733. July 1985. p. 15.
[2]Ibid., p. 21.

must undergo a 30-day quarantine period. The effect of this regulation has been to limit annual imports of swine from the US to a small quantity of breeding stock.

United States regulations limit imports of swine from countries that exhibit signs of rinderpest and foot-and-mouth diseases. Canada has been fairly successful in avoiding these diseases, although outbreaks have occurred.

A controversy in the spring of 1985 over the use of chloramphenicol also curtailed trading activity temporarily in some states. The therapeutic drug was authorized for use in swine herds in Canada but banned south of the border. American farmers contended that imports of swine and pork from Canada should be stopped, because residues of the drug in pork presented a potential health hazard and detracted from the image of the pork industry. As a result, governments in South Dakota, Iowa, Nebraska, Wisconsin and Minnesota placed an import ban on Canadian swine and pork. The Canadian government subsequently prohibited the drug's use in Canada. The states involved have since lifted their import bans.

Packaging and labelling requirements are also used periodically in both countries to inhibit trading activity. For example, the requirement that American pork products be labelled with both the French and English languages for entry to Canada has served as a non-tariff barrier at times. It is important to note that it is often the threat of enforcement of non-tariff barriers, rather than actual enforcement, that serves as the deterrent to trade.

Other Factors Influencing Trade

Of more notable impact on North American trading patterns in recent years has been the substantial shift in the US-Canadian exchange rate (Figure I-1). In 1976, the two currencies were almost at par ($0.986 Canadian per US dollar). By 1986, however, the Canadian unit of exchange had fallen to $1.386 per US dollar.[3] The rise in purchasing power of the US dollar in Canada has encouraged increased trading activity over the period.

Several other factors have been cited as influencing recent Canada-US trade patterns, particularly in the swine trade. These include:

1. A decline in US swine production, forcing packers to procure slaughter hogs from other sources to maintain operations at capacity and minimize losses.
2. Canada's loss of market share in the Japanese market in 1984. Producers had increased production with this market potential in mind. With the re-entry of Denmark into the Japanese market, Canadians had to look elsewhere for outlets.
3. Rationalization of the Canadian and US meatpacking industries in the early 1980s.
4. Temporary labour problems (strikes, lockouts) in the Canadian packing industry. At the same time, US packers were successful in obtaining wage rollbacks and settlements in contract negotiations.
5. These wage differentials allowed US packers to bid more for Canadian product and remain competitive.
6. Proximity of Canadian hog/pork production to US meatpackers and

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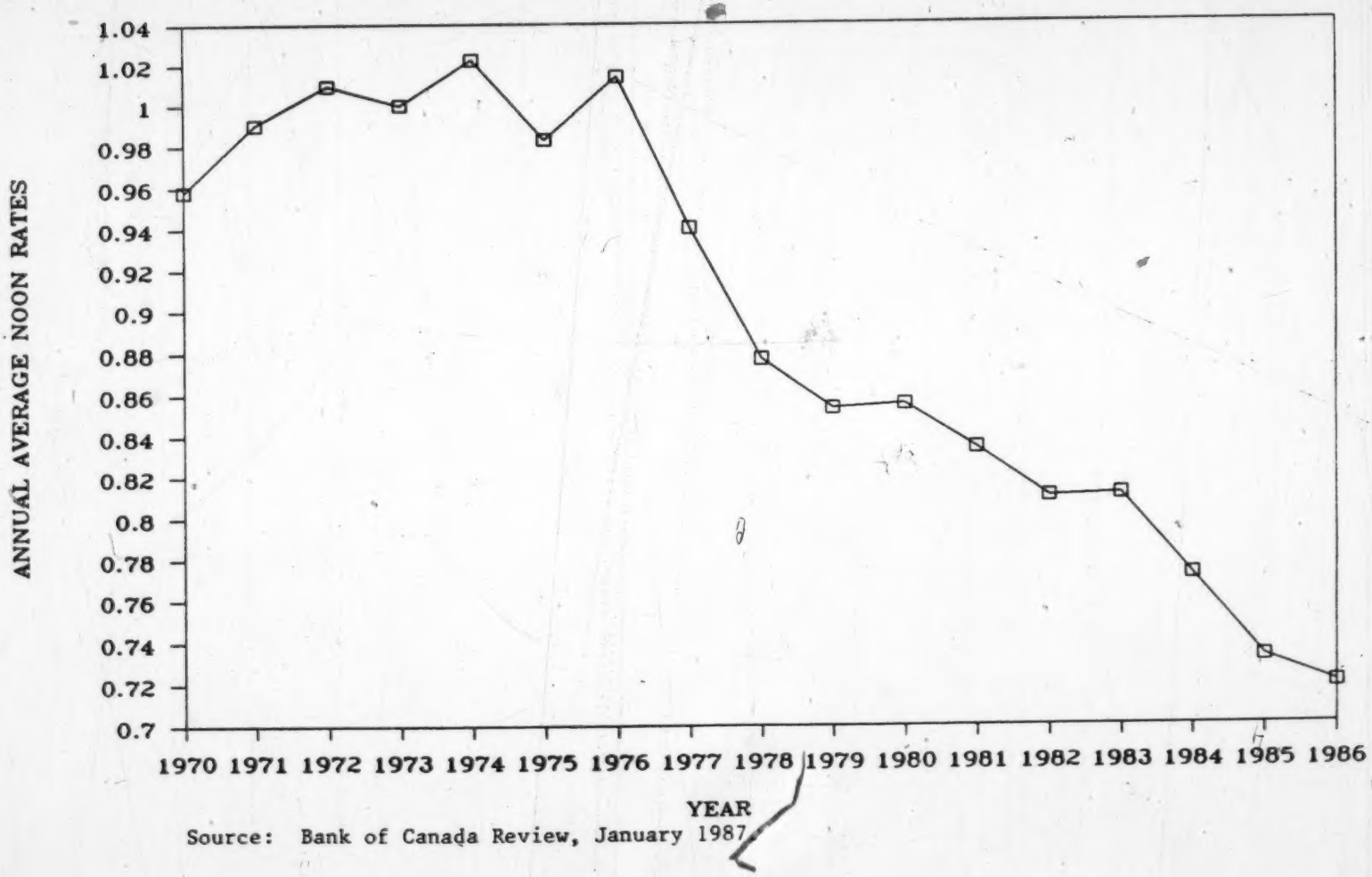
[3]Exchange rates (expressed as average noon rates) from "Bank of Canada Review," January 1987.

Figure I.1 Canadian Dollars Expressed as US Dollars, 1970-1986




Source: Bank of Canada Review, January 1987

consumer markets.

7. Low (relative) Canadian corn and feedgrain prices.
8. Leaner Canadian products which were perceived by US consumers as more desirable.
9. Ontario, Quebec and federal government subsidies paid to Canadian swine producers, encouraging expansion or maintenance of the existing production base. The production in excess of domestic demand needed market outlets.

B. HISTORICAL TRADING PATTERNS

Canada has been a net exporter of pork with the US in most years since 1970 (Figure I-2). In that year, the net trade balance in pork was 34.8 million pounds.[4] By 1973, however, this amount had dropped to 15.3 million pounds -- a 56 percent decline.

The 1974 to 1978 period was one in which Canada was a net importer of pork from the US. At the United States' peak export year of 1977, Canada experienced a net import balance of 180.7 million pounds. By 1979, however, Canada had returned to a net export position. The net export balance then rose from 23.2 million pounds in 1979 to 418.3 million pounds in 1986.

At its peak in 1977, US pork exports to Canada represented 15 percent of Canadian consumption, but only one percent of US production. In contrast, Canadian pork exports across the border have in recent years accounted for up to 30 percent of our production, but only four percent of US consumption. Traditionally, Canadian pork has accounted for 80 to 100 percent (by quantity) of total US imports. The US has

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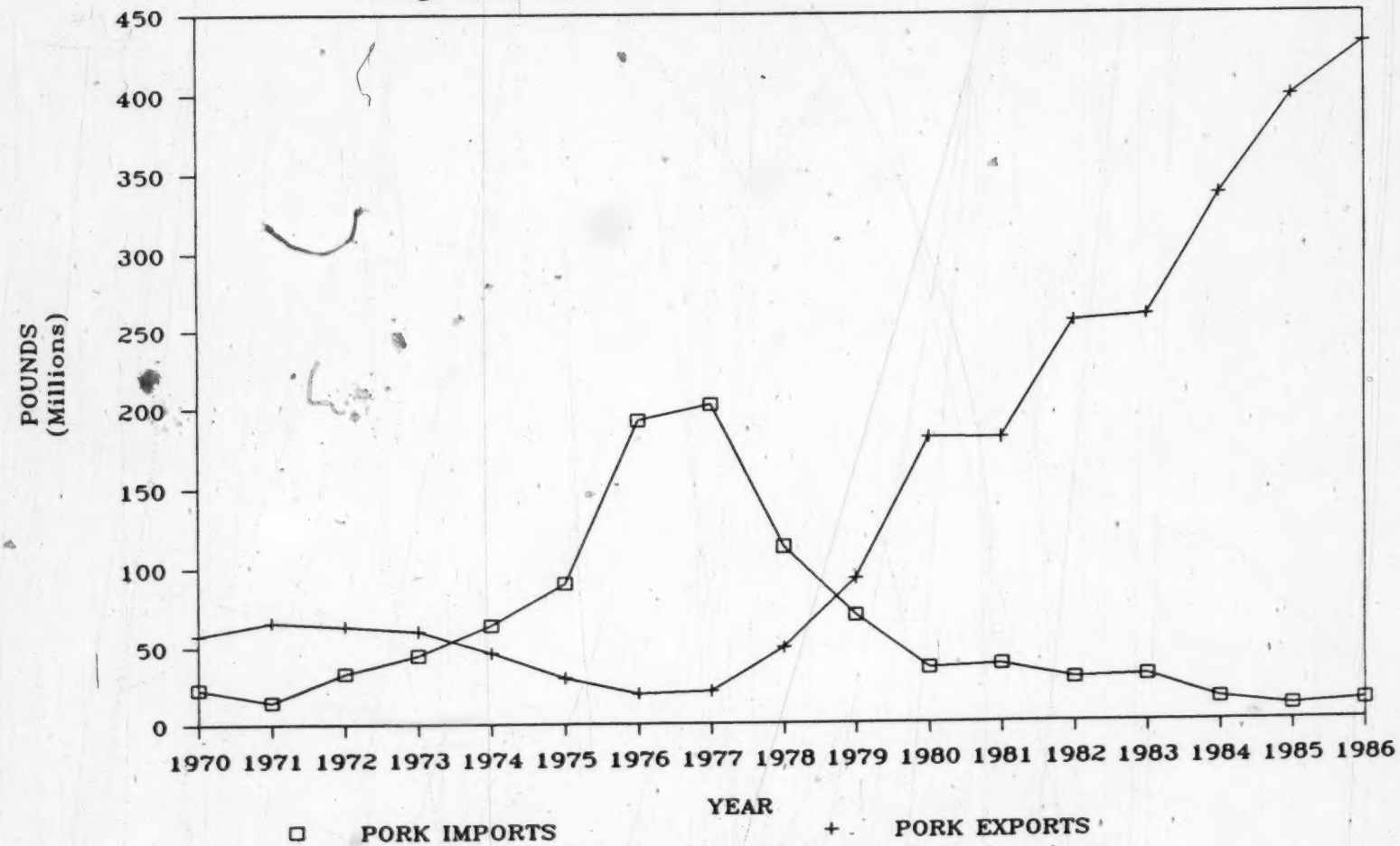
[4]All figures in this section are from Agriculture Canada "Livestock Market Summaries."

Figure I.2 Total Pork Trade With The US, 1970-1986




Source: Agriculture Canada "Livestock Market Summary." Various issues.

generally contributed between 80 and 90 percent of Canada's total pork imports. The two countries have clearly experienced a strong interdependence in pork trade in recent years.

Swine have historically traded only south, due to Canadian health regulations prohibiting the entry of US swine. Numbers of head exported have fluctuated widely since 1970, ranging from 9,080 to a peak of 1.1 million in 1984 (Figure I-3). Between 1981 and the first quarter of 1985, swine from Canada to the US exhibited a steady increase. From 1981 to 1982, they rose from 90,292 to 153,122 head and in 1983, exports increased to 273,377 head. Exports rose to 1.1 million head in 1984, but declined to 868,710 head the following year, due to the imposition of a countervailing duty in the second quarter of 1985. By 1986, swine exports to the US had dropped to 301,560 head.

The net trade balance in swine and pork products since 1970 has been in Canada's favour in all but one four-year period (Figure I-4). Between 1970 and 1974, Canada experienced an annual average net surplus with the US of $26.1 million.[5] From 1975 to 1978, an average surplus of $56.1 million per year was realized by the US. Finally, from 1980 to 1986, the net trade balance in swine and pork shifted back to Canada's favour, rising from $134.4 million in 1980 to $494.2 million in 1986.

The net import period experienced by Canada between 1975 and 1978 can be viewed as a deviation from the general trend in trading patterns. Between June 1973 and July 1975, Canadian swine inventories dropped by 30 percent.[6] The decline was especially pronounced in Western Canada.

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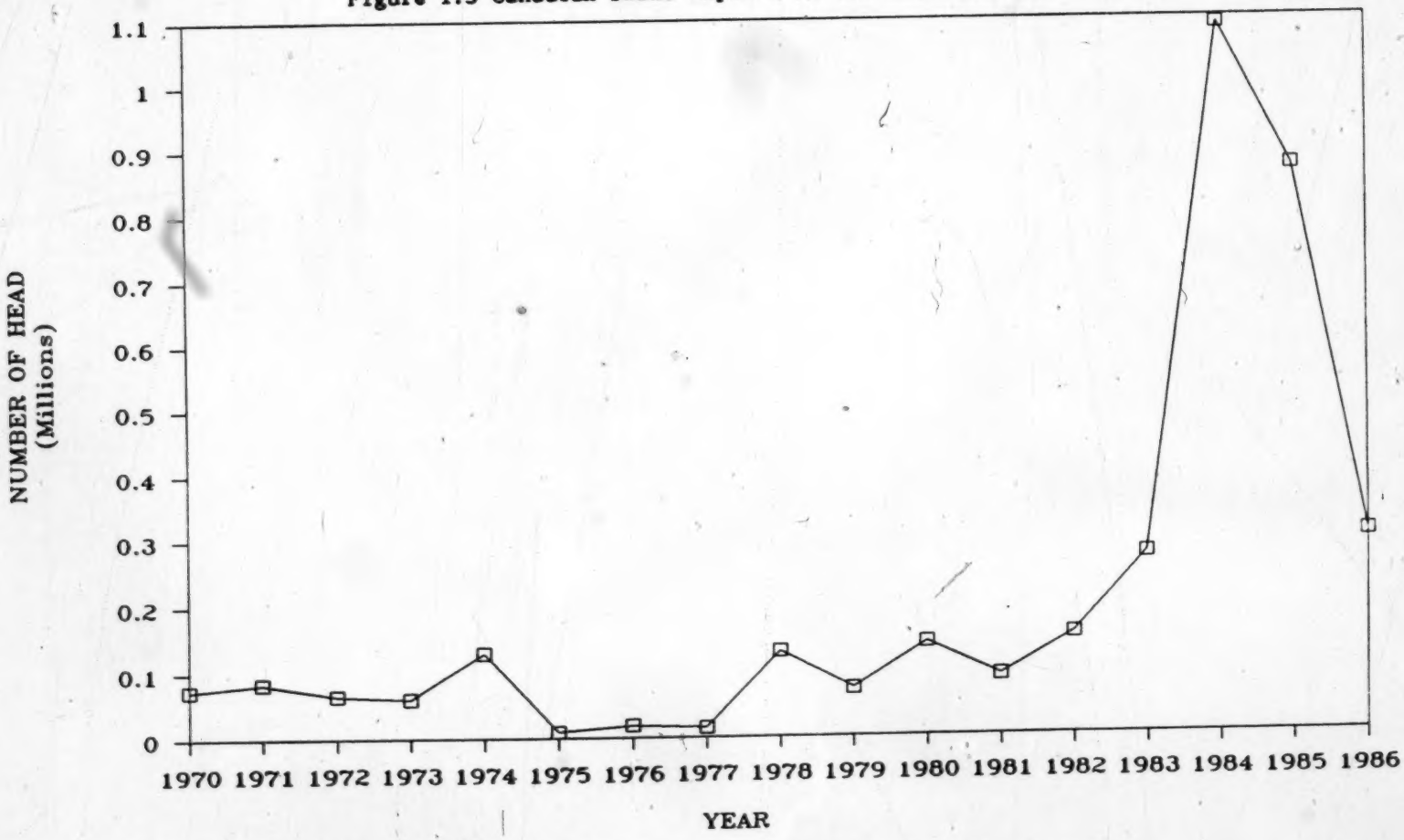
[5] Figures in this section were calculated from Statistics Canada Publications "Exports by Commodities" and "Imports by Commodities," and are expressed in (nominal) Canadian currency.

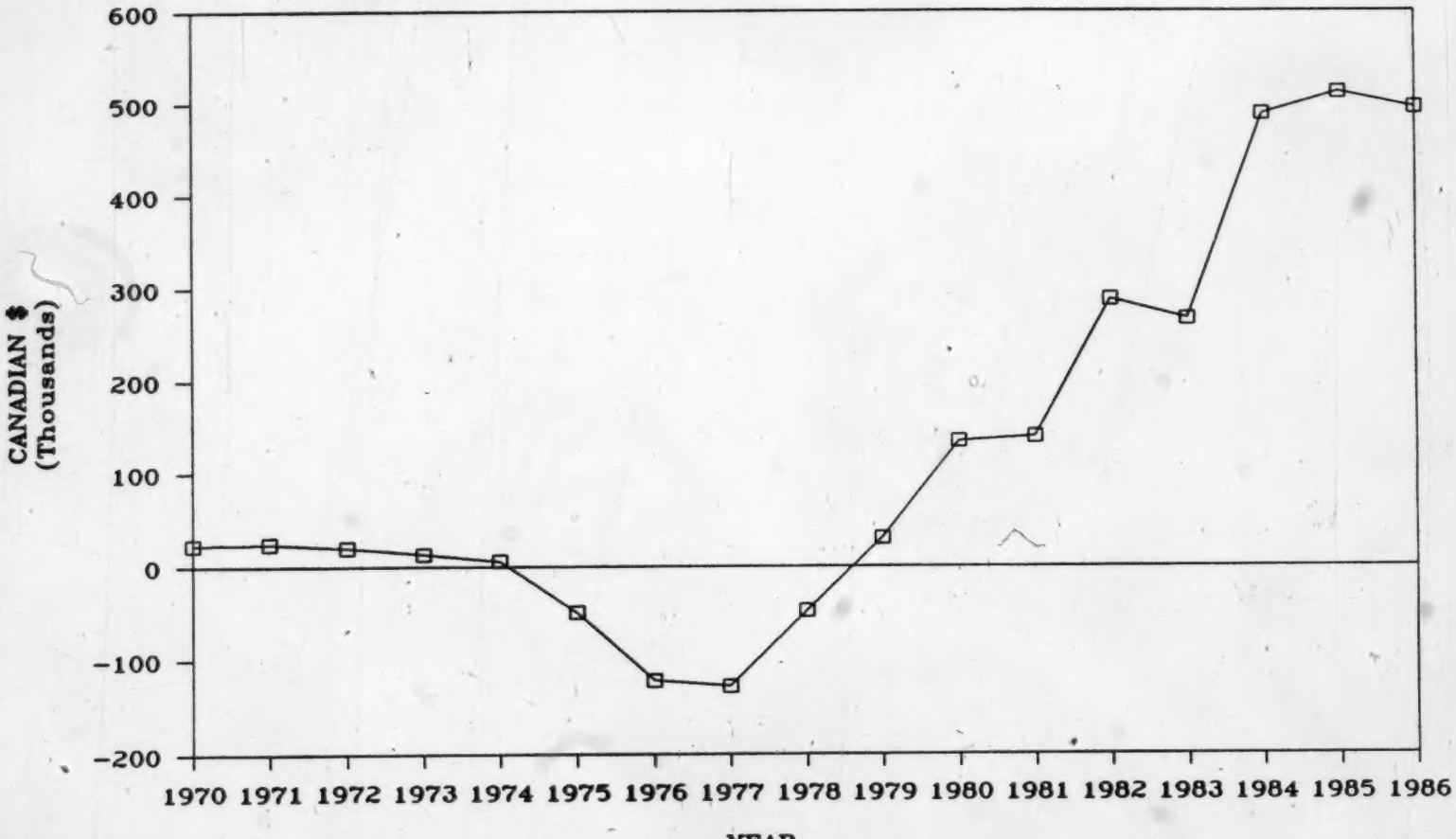
[6] C. Goodloe. "U. S. Producers and the Countervailing Duty Case Against Canadian Pork and Hogs," Western Economic Review. Volume 4, Fall 1985. p. 23.

Figure I.3 Canadian Swine Exports To The US, 1970-1986




Source: Agriculture Canada "Livestock Market Summary." Various issues.

Figure I.4 Canada's Net Trade Balance With The US, 1970-1986




Source: Statistics Canada "Exports By Commodities" and "Imports By Commodities."

Grain prices had risen sharply due to extraordinarily large Soviet grain purchases, and farmers had chosen to market their grain directly rather than feed it. The fall in inventories and resultant slaughter numbers left the Canadian market open to US imports. Canadian swine numbers began to rebuild in 1977, grew steadily through 1981, and have since remained at relatively high levels. The trade balance correspondingly shifted back to Canada's favour.

In recent years, pork exports from Canada to the US have risen, while swine exports have declined. A primary cause of the drop in swine exports has been the enforcement of a countervailing duty since April 1985. The following section contains an outline of the events leading up to its imposition.

## C. THE COUNTERVAILING DUTY INVESTIGATION

During the late 1970s and early 1980s, swine producers in both Canada and the US had experienced several consecutive years of low profitability.[7] Many producers had incurred debt in the late 1970s to expand or build new facilities. The large debtloads and low returns were resulting in financial stress for many producers. In the meantime, Canadian imports of swine had increased substantially. This trading activity had become quite visible as US producers observed the steady flow of Canadian truckloads of hogs entering their states.

American producers became concerned that the upswing in Canadian imports in the early 1980s was responsible for their depressed market prices and low net farm incomes. In particular, they felt that government subsidies accruing to Canadian producers were providing their

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[7] C. Goodloe. op. cit. p. 19.

northern neighbours with an unfair trade advantage.[8]

American producers began to express their concerns in late 1983. The complaints became more vociferous in early 1984, as monthly hog imports were almost tripling from the same time period in 1983.[9] In May 1984, the Agriculture Committee of the US House of Representatives held hearings in which US producers and government officials testified on the impact of Canadian imports on the US swine industry. The Senate Agriculture Committee held similar hearings in August 1984.

In June 1984, at the request of the Senate Finance Committee, the United States International Trade Commission (USITC) commenced an investigation into competitive conditions between the US and Canadian swine industries. The investigation was of a fact-finding nature and not related to the countervailing duty case. However, a concerted lobbying effort by US producers to the National Pork Producers Council (NPPC), their representative body, culminated in the filing of a petition with the USITC and the US Department of Commerce (USDC) on November 2, 1984, prior to completion of the fact-finding investigation. The petition alleged that US swine producers were suffering "material injury," or being threatened with "material injury," by imports of Canadian swine and pork products.[10] The NPPC called for the imposition of a

---

[8]Hogs have been a named commodity in Canada since federal stabilization legislation was enacted in 1958. Until 1975, the level of support was determined on the basis of historic prices (previous 10 year averages) and the minimum (normally the actual) support level was set at anything above 80 percent of this historic average. In the present amended version, the historic average is reduced to the previous five years, the market return support is raised to 90 percent, and the concept of guaranteeing support of gross margins at some historic level is introduced by adjusting the current support by any increases in cash costs above the previous five year average. (Canadian Pork Council "Submission of the CPC to the USITC" - September 1984. p. 3).

[9] J. C. Gilson. "The U. S.-Canadian Hog War," Western Economic Review. 4(3), Fall 1985. p. 4.

[10]Material injury is defined as harm to an industry which is not

countervailing duty on Canadian imports.[11] The USITC responded by launching an extensive investigation into Canadian hog production, including a careful scrutiny of government subsidy programs. The Canadian programs considered in the investigation were: the Agricultural Stabilization Act, the Record of Performance Program, the Hog Carcass Settlement Program, and 11 provincial stabilization programs operating in the 10 provinces.[12]

The Canadian view on the matter, however, was that stabilization programs were not established with the intent of influencing trade patterns between the two countries. It was noted that during a period of rapidly rising marketings (1976 through 1980), federal support payments were non-existent, and provincial plan payouts were minimal.[13] For example, from 1975 until 1981, production increased by 63.2 and 103.6 percent in Ontario and Quebec, respectively. Support programs were thus

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[10](cont'd) inconsequential, immaterial or unimportant.

[11] Under US law, private industry may file countervailing duty (CVD) petitions alleging injury from imports that receive foreign subsidies. CVD cases are authorized by the Tariff Act of 1930, as amended most recently in 1984. A CVD case is basically a four-part process involving the International Trade Administration (ITA) of the Department of Commerce, and the USITC. The ITA is responsible for determining the existence and level of subsidization, while the USITC examines claims of material injury. After the ITA judges that the petition provides evidence of foreign subsidies, the ITC then has 45 days to determine whether there was "reasonable indication or threat thereof" of injury to the domestic industry due to imports. The material injury test is mandatory for US CVD cases under the Trade Agreements Act of 1979, if the case involves a government that is signatory to the GATT Code on Subsidies and Countervailing Duties. Canada is a signatory to this Code. The GATT Agreement provides very general guidance with respect to the definition and measurement of subsidies and material injury. Under the US legislation, the definition and measurement of subsidies and material injury are what the USDC and USITC determine them to be. The ITA must then make decisions in the absence of clear legislative guidance, and relies as much on precedent from previous cases as on economic theory as to what constitutes a subsidy.

[12]United States International Trade Commission. op. cit.

[13]Canadian Pork Council. "Submission of the Canadian Pork Council to the United States International Trade Commission." September 1984. p. 15.

essentially inoperative during the most recent expansionary phase in Canadian swine production. The Canadian Pork Council (CPC) also pointed out that in the period under study (April 1, 1983 to March 31, 1984), Canadian support payments averaged less than five percent of prices received by producers.[14]

The countervailing duty investigation entailed five months of public hearings and briefs, where the CPC, the NPPC and other interested parties were invited to present their cases. The outcome of this preliminary investigation favoured US producers; it was determined that certain benefits that constituted subsidies were being received by Canadian swine producers during the period under study.

On April 3, 1985, a provisional countervailing duty of $0.0376 per pound on swine and $0.053 per pound on pork and pork products was enforced.[15] These duties were judged to be equivalent to the federal and provincial subsidies received by Canadian producers. For the following three months, any of the Canadian commodities crossing the border were subject to bond posting in the amount of the duty. Funds collected were placed in an escrow account pending the final outcome of the investigation.[16]

Further investigation by the USITC determined that Canadian swine producers, but not pork and pork products processors, were in fact receiving subsidies, and these government support programs were the

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[14] B. Gilmour and M. Cluff. "Canadian Stabilization Initiatives and Their Effects on The Welfare of American Pork Producers," Canadian Farm Economics. 20 (1), 1985. p. 18.

[15] C. Goodloe. op. cit. p. 5.

[16] In the case of bond posting, the funds are returned to the exporter if the case is terminated at any time by a negative decision. If a positive decision is arrived at, the bonding deposits in the escrow account plus the duties subsequently collected are turned over to the US Treasury.

source of material injury suffered by US producers. On July 25, 1985, the duty on pork and pork products was abolished, while that on swine was adjusted to $0.0439 per pound liveweight and made permanent.

The USITC decision is subject to review at twelve month intervals. If it is determined that Canadian subsidization has been altered, the countervailing duty must be adjusted accordingly.

It has been estimated by one author that losses to Canada as a result of the countervailing duty imposed in April 1985 were:

1. Immediate losses for the April 3 to December 31, 1985, period were approximately $187 million.
2. Projected annual losses of between $300 million and $500 million in the long run due to an estimated 25 to 35 percent drop in production from 1985 levels.
3. A substantial multiplier loss to the Canadian economy.[17]

It must be remembered, however, that the increased exports of pork and pork products in place of swine has likely offset some of these losses to the overall economy.

The benefits generated from the exportation of swine and pork products accrues not only to producers and packers, but also to other sectors of the economy. The ramifications of the duty, therefore, are of great concern to the Canadian industry. Given the protectionist posture adopted by US Congress in recent years, as evidenced by progress or lack thereof in the "freer trade" talks between Canada and the US, it is likely that it will continue to be an issue.

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[17] J. C. Gilson. op. cit. p. 8.

## D. SUMMARY

The preceding discussion has outlined the interdependencies between the Canadian and US swine industries. The heavy reliance on trade between the two countries suggests that the Canadian markets operate in a much larger North American market. These physical and financial ties between markets would indicate a close relationship in price movements, as well. Market adjustments in one country would be expected to be transmitted to the other country via the trade linkages.

The countervailing duty imposed by the US on Canadian swine imports is expected to have direct and indirect impacts on the Canadian industry. It is the intent of this research to study the impacts of the duty on North American hog pricing relationships. Specific reference will be made to aspects of pricing efficiency in the Canadian markets.

## E. OBJECTIVES

The primary objective of the study is to examine the effects of the increase in movements of swine from Canada into US markets on US prices. The secondary objective of the research is to evaluate the effect of the countervailing duty on pricing efficiency in the Canadian hog markets, including an analysis of the lead-lag structure of the price transmission process. These objectives will be met by studying the Western Canada, Eastern Canada, and the combined seven US midwest states (US-7) hog markets.[18]

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[18]For the purposes of this research, Canada has been segmented into two regions- Western and Eastern. However, it should be noted that the majority of Canadian hogs are produced in Central Canada (Ontario and Quebec).

## F. HYPOTHESES

The following hypotheses are postulated:

1. The substantial increase in imports of swine from Canada did not exert any statistically significant impact on the price discovery mechanism in US markets.
2. The presence of the countervailing duty has had no influence on pricing efficiency in the Canadian hog markets.

## G. LIMITATIONS OF THE STUDY

The exclusion of the Quebec market in the empirical analysis, due to data unavailability, is seen to be a major limitation in the study. The Quebec hog industry is characterized by vertical integration- a unique arrangement in Canada's hog industry. As such, prices are not reported for Quebec markets. However, these prices are formula-based on Ontario prices. The Ontario price can therefore be used as a reliable representation of the Eastern Canada price.

The results of the study are also likely to be influenced by the market structure of the Alberta hog industry. The "Hog Wars" between the province's Marketing Board and one slaughtering plant in 1985 and 1986 is expected to be very influential on performance of the industry over that time period. In addition, labour/management problems at one of the plants is expected to play a role. However, a description of these activities is beyond the scope of the study.

Variations in the packing plant industry structure between Canada and the US may also influence the outcome of the research. While the Western Canadian industry resembles a strictly oligopsonistic structure, the US markets under study lie somewhere between perfect competition and

oligopsony.

H. FORMAT

The second chapter provides an overview of the structure of the US and Canadian pork industries. A theoretical framework incorporating price determination under perfect competition and oligopoly,and the pricing efficiency concept of industrial organization theory, are discussed in Chapter 3. The subsequent chapter contains a review of analytic techniques. Chapter 5 outlines the methodology that will be utilized in the empirical analysis, including a description of data, a critique of previous methodologies used to evaluate agricultural prices, a discussion of the vector autoregression technique and the model-building process. An interpretation of the empirical results is contained in Chapter 6, and a summary, conclusions and recommendations completes the study in Chapter 7.

# II. A PROFILE OF THE NORTH AMERICAN PORK SYSTEM

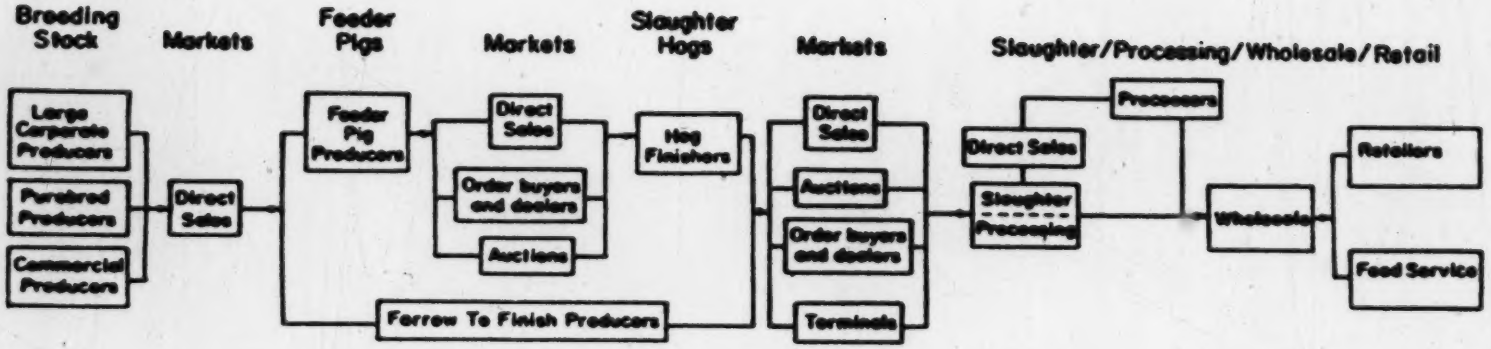
## A. INTRODUCTION

The North American pork system is an important contributor to both the US and Canada's food supply and to the income of many farm producers. It is also a customer for many input sectors, including feedgrains and oilseeds, capital and labour.

The pork system consists of a series of interrelated functions that transform feedstuffs into pork cuts and other pork-containing products purchased by consumers. Figure II-1 depicts the US system. The Canadian system is very similar, although variations exist in the marketing component. While all of these functions are occasionally performed by one operation (e.g. a feedgrain producer raising and slaughtering a hog for home consumption), the system typically involves a series of firms specializing in separate activities. The total system is linked by various marketing arrangements. In recent years, this network has become more technologically sophisticated and capital-intensive in response to changes in the overall economic climate of the two countries.

The changing structure of the North American pork system results in complications for any market analysis of the sector. As its organization has evolved into a more specialized and industrialized production/processing system, the nature of price behaviour has also changed. To study price movements of the commodity, then, the researcher must first possess a sound knowledge of the industry structure and the factors affecting supply and demand. The current chapter is devoted to an overview of the North American pork system. As the study objectives

Figure II.1 The US Pork Production And Marketing System




Source: M. Hayenga, V. Rhodes, J. Brandt and R. Deiter. The U. S. Pork Sector: Changing Structure and Organization. Iowa State University Press. Ames, Iowa. 1985.

deal with pricing in slaughter hog markets, the discussion will be limited to a description of the production, marketing and processing sectors.

## B. THE CANADIAN INDUSTRY

### Importance Of The Industry

Hog cash receipts have made an important contribution to total farm cash sales over the years. Table II-1 shows total farm receipts, livestock receipts, and hog receipts for Canada, Eastern Canada, and Western Canada from 1970 to 1985.[19] It can be seen that hog receipts in Eastern Canada made a particularly large jump over the period. Total livestock receipts increased by approximately the same proportion in all parts of Canada, while Western Canada experienced the largest percentage increase in total farm receipts.

In 1970, hog cash receipts captured 19, 18 and 20 percent of total livestock receipts in Canada, Eastern Canada and Western Canada, respectively. By 1985, these shares had adjusted slightly to 18, 20 and 15 percent for the three regions. As a proportion of total farm marketings, hog receipts decreased from 12 percent to nine percent between 1970 and 1985 for Canada, remained at 14 percent for Eastern Canada and dropped from 11 percent to five percent in Western Canada. The trend in the West accentuates the increasing importance of the grains and oilseeds sector in the Prairie agricultural economy in the early 1980s.

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[19]Statistics Canada "Farm Cash Receipts". Various issues.

Table II.1 Farm Cash Receipts- Canada, 1970 and 1985

| | Total Farm Receipts | | | Total Livestock Receipts | | | Hog Receipts | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1970 | 1985 | % Change | 1970 | 1985 | % Change | 1970 | 1985 | % Change |
| Western Canada | 1.6 | 6.8 | 425 | 1.0 | 3.8 | 280 | .2 | .58 | 190 |
| Eastern Canada | 2.4 | 8.4 | 350 | 1.6 | 6.0 | 275 | .287 | 1.2 | 318 |
| Total Canada | 4.0 | 15.2 | 380 | 2.6 | 9.8 | 277 | .487 | 1.8 | 271 |

All figures expressed in billions of dollars.

Source: Statistics Canada Farm Cash Receipts, various issues.

Total livestock sales as a percentage of farm sales have lost ground in recent years. In 1970, they captured 65 percent of Canada's farm sales; this share dropped to 51 percent in 1985. The Western region has experienced the most noticeable change, dropping from 53 percent to 36 percent, while Eastern Canada has declined only marginally from 76 percent to 71 percent.

A large share of Canada's national income is also generated from industries either directly or indirectly related to hog production. For example, in 1984 the meat and meat products manufacturing industry (of which pork is an important part) was ranked third among Canada's leading manufacturing industries (classified in terms of the value of goods of own manufacture).[20] The industry was ranked first on the Prairie provinces. Nationally, it was comprised of 536 establishments (352 in Eastern Canada and 184 in Western Canada), with a total value of shipments exceeding $8.7 billion and a value-added of $1.5 billion. The industry provided employment for 30,836 people. The majority of these were employed in Eastern Canada (20,332), with the remainder (10,504) employed in Western Canada.

It has been estimated that for every dollar spent on wages in the meatpacking industry, over two dollars are generated in value-added production.[21] In addition, jobs and investment activities are created in other industries handling pork products.

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[20]Statistics Canada "Manufacturing Industries of Canada: National and Provincial Areas 1984". p. 10.
[21]J. Gilson. "The Pork Industry in Manitoba." Manitoba Department of Agriculture. July 1979. p. 12.

Structure Of Swine Production

The manner in which swine are produced in Canada has changed markedly over time.[22] Several decades ago, swine were popular on Canadian farms because they consumed a variety of feeds, were efficient at feed conversion, were prolific producers and were compatible with other farm enterprises, particularly crop production. They could be raised with minimal capital investment, providing the operator had a supply of feed and ample labour. These characteristics made swine production an important source of cash flow for the farmer. It should be noted that hogs produced in this time period were a "lardier" type than what is produced today. In the husbandry sense of the word, they were efficienct feed converters, but in the meat science sense they were not. Great progress has been made in recent years in Canada toward producing a leaner, meatier type of hog. This success is largely attributable to advances in the grading system, which encouraged production of the type of hog demanded by consumers.

While many of these factors hold true today, swine production has evolved into a specialized, total confinement, capital-intensive business in Canada. The structural changes were triggered primarily by the introduction of the leaner type of hog, which lent itself readily to total confinement production practices. Commercialized use of antibiotics to control disease in large herds housed in close quarters, and the development of specially constructed buildings designed to provide climate control and automated feeding and cleaning also contributed to the changes.[23]

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[22]For the purposes of this research, "swine" will be used to refer to all members of the species, including breeding stock and market animals. "Hogs" will refer to market stock only.

[23]Statistics Canada. "The Changing Profile of the Canadian Pig Sector."

The following discussion presents some structural changes that have occurred in Canada's swine production industry.

1. Historical Overview of Swine Production: Except for cyclical adjustments, total Canadian swine inventories grew steadily from 2.4 million head in 1901 to 9.9 million head in 1981.[24] Numbers in Eastern Canada fluctuated between two and three million head until 1961, when swine inventories started increasing and peaked in 1981 at seven million head. Quebec was largely responsible for this growth, moving from 17 percent of total Canadian production in 1961 to 35 percent in 1981.

Swine production in Western Canada was more volatile, reflecting the feedgrain-livestock interface. The industry there was characterized by many peaks and troughs, fluctuating between 241,800 and 4.11 million head since 1901. In 1981, swine inventories were at 2.9 million head. The variability in this region has been attributed primarily to conditions in the feedgrain markets. Historically, grain producers entered swine production in times when surplus grain stocks rose, and subsequently exited the industry when feedgrain market conditions improved. It should be noted, however, that the shift towards large, capital-intensive enterprises in recent years has tempered this volatility somewhat.

The number of farms reporting swine steadily declined over the years. In 1941, 65 percent of all census farms in Canada kept some swine.[25] In 1981, 55,649, or 18 percent of census farms, reported swine. The East accounted for 52 percent of these farms.

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[23](cont'd) Working Paper Number 9. Catalogue Number 21-521E. May 1985. pp. 5-21.

[24] Unless otherwise stated, all figures are from Statistics Canada "Censuses of Agriculture."

[25]A census farm is defined as an agricultural holding with sales of agricultural products of $250. or more during a 12 month period.

The distribution of swine inventories in Canada experienced a major shift since the early years. In 1901, Eastern Canada held 90 percent of Canada's inventories. This figure dropped to 72 percent in 1911 and remained in that range until 1941, when it decreased to 47 percent. By 1981, Eastern Canada accounted for 71 percent of Canada's swine population. The distribution of Canada's swine, as of 1981, is presented in Table II-2.

2. Size of Operations: Canada's swine industry has at one extreme a large proportion of producers accounting for a relatively small percentage of the population, while at the other end of the spectrum a small number of farmers account for an increasing number of head. Farms with less than 20 head represented 4.8 percent of total swine in 1971 and 1.6 percent in 1981. However, this inventory was held by 44.7 percent and 43.1 percent of farms reporting swine in 1971 and 1981, respectively. Farms with 2501 or more head represented 2.6 percent of inventories in 1961 (0.1 percent of farms) and 15 percent in 1981 (0.6 percent of farms). Nine percent of the farms reporting in 1981 had herd sizes of over 500 head and held 62 percent of the inventory.

The average herd size in Canada grew from 66 to 177 head between 1971 and 1981. In Eastern Canada, the size increased from 75 to 239 head, while in Western Canada it went from 59 to 109 head. Quebec had the largest average herd size in 1981, at 430 head.

3. Types of Swine Enterprise: Canada's swine industry can be classified into three main types of enterprise: farrow, farrow-to-finish, and finish. A farrowing operation is one in which farmers raise piglets from birth and sell them to finishers for feeding out. Farrow-to-finish operators complete all phases of production, from birth to selling for

Table II.2 Distribution Of Swine Production In Canada - 1981

| | Percentage of Production | |
|---|---|---|
| Western Canada | 29 | |
| B.C. | | 3 |
| Alberta | | 12 |
| Saskatchewan | | 6 |
| Manitoba | | 8 |
| Eastern Canada | 71 | |
| Ontario | | 32 |
| Quebec | | 35 |
| Maritimes | | 4 |
| Total Canada | 100 | |

Source: Statistics Canada Census of Agriculture, 1981.

slaughter. Finishers buy swine from farrowing operations and feed to market weight.

The distribution of swine inventories by types of enterprise is shown in Table II-3. Farrow-to-finish operations dominate inventories, particularly in Western Canada. Finishing operations are somewhat more predominant in Eastern Canada than Western Canada, as are farrowing enterprises.

4. Type and Mix of Farm Enterprise: In 1981, 11 percent of the swine inventory was located on farms that reported swine only; 33 percent was on farms reporting swine and cropland; five percent was on farms reporting swine and other livestock; and 51 percent was on farms with swine, cropland and other livestock. It can be seen, then, that 84 percent of the swine inventory, representing 91 percent of swine farms, was raised on farms which also grew crops. Fifty-six percent of the swine inventory, representing 75 percent of swine farms, was on farms reporting other livestock as well. The proportion of farms reporting swine only was five percent in 1981.

4. Type of Farm Organization: Individual proprietorships dominated swine production in Canada in 1981. Individual or family operations accounted for 87 percent of all swine farms, compared to 92 percent in 1971. This trend was virtually identical in Western and Eastern Canada. Partnerships accounted for 9.3 percent of farms; corporations, 2.9 percent; and other farm organization types (Hutterites, institutions, and cooperatives) represented 0.5 percent of all farms reporting swine.

Table II.3 Types Of Swine Enterprise In Canada - 1981

| | Farrow-to-Finish | Finishing | Farrowing |
|---|---|---|---|
| Western Canada | 69 | 20 | 11 |
| Eastern Canada | 50 | 31 | 19 |
| Total Canada | 56 | 28 | 16 |

* Figures reported as percentages of total pig inventories in each region.

Source: Statistics Canada Census of Agriculture, 1981.

Marketing

Canada's hog marketing system has evolved over the years from a highly decentralized and localized system to the central selling process that is in place in most provinces today.[26]

At the beginning of the century, slaughter hogs were marketed through several channels, including terminal markets, direct to packers and country auctions. Prior to 1920, the terminal market was the most prevalent channel for farmers to sell their commodity.[27] The dependence of terminal markets on the railways as the primary mode of livestock transport facilitated the growth of these markets.

The introduction of rail grading for hogs and the development of the trucking industry in the 1920s caused a major restructuring in Canada's hog marketing system. Producers began to ship most of their hogs direct to the packing plants. Prices were negotiated on a private treaty basis between the two parties. During this era, hogs were also sold via community auction sales, independent livestock dealers, decentralized packer buying stations, and cooperative livestock shipping associations.

Private shippers and local cooperative marketing associations were gaining popularity in this period. Private shippers assembled hogs, tattooed them and arranged for shipment to packers. Cooperative associations performed similar services, but they represented producers as selling agents rather than packers as buying agents.

When hogs were sold through commission agents for direct delivery to packers, a floor price formula was generally used as some guarantee

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[26]As the research focuses on pricing in slaughter markets, feeder and breeding pig marketing will not be discussed.

[27]J. Gilson. "Evolution of the Hog Marketing System in Canada." Working Paper E/I 2, Economic Council of Canada. January 1982. p. 17.

of price to producers. Most packers applied the same floor price formula to their purchases in order to remain competitive in the market. The majority of the producers preferred this method of selling over the terminal yards. They at least had some idea of the going price and a guarantee before shipping their hog. The degree of competition in the terminal markets was also suspect at the time, and allegations of collusive buyer behaviour were common.

Eventually, however, hog producers began to feel that they did not possess enough bargaining power in the marketplace. They perceived that the one-on-one negotiations in direct sales were less than competitive, and they began to search for alternatives to "level the playing field" in price setting.

After considerable research into alternative selling procedures by livestock groups and governments in the various provinces, hog marketing boards and commissions were initiated. These central selling agencies, vested with powers given them by provincial marketing legislation, evolved with the mandate of achieving a more competitive marketing system, or more direct bargaining strategies with the packing industry. They were given sole legal authority to sell hogs in their respective provinces.

Ontario was the first province to move towards a compulsory marketing plan for hogs, with the establishment of a marketing board in 1946. It was not until 1960, however, that producers were actually required to ship their hogs to the board. New Brunswick and Nova Scotia established boards in 1951 and 1953, respectively. The next province to adopt a central selling agency was Manitoba, with the formation of a voluntary commission in 1964. This commission was replaced with a

marketing board in 1972. The Alberta Hog (later changed to "Pork") Producers Marketing Board was launched with a producer plebiscite in 1968. The provinces of Saskatchewan and Prince Edward Island established commissions in 1972. B. C. was the most recent province to implement a hog marketing commission, in 1980. Today, Newfoundland and Quebec remain the only provinces in Canada that do not sell hogs by a central selling agency.

Sixty-five percent of Canada's slaughter hogs are now sold by provincial boards and commissions.[28] The hogs are graded by Federal graders and carcasses are sold on an index 100 basis. The grading system determines any differential to be paid to producers.

The specific selling and pricing techniques of boards and commissions vary among provinces. In B. C., for example, producers deliver their hogs direct to packers and are paid a contract price negotiated by the Commission. This price is based on the weekly average price in the Alberta market, plus transfer costs. The Saskatchewan Commission contracts with packers for hog sales and also negotiates the conditions of sale on behalf of the province's producers. A formula is used which includes daily hog prices in Toronto, Winnipeg, Edmonton and Omaha, plus weekly wholesale pork prices.

The Alberta Board conducts hog marketings by three methods: contract sales, where volumes are set; residual sales (above contract volumes); and negotiated sales. Ontario follows a daily electronic auction selling procedure. The Manitoba Board utilizes a Dutch Clock auction to sell the province's hogs.

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[28]Ibid. p. 15.

Three of the Maritime provinces -- New Brunswick, Nova Scotia and Prince Edward Island -- sell hogs on the basis of a price formula. New Brunswick and Nova Scotia generally set their prices first, using Ontario prices and current local market trends. Prince Edward Island then follows their example.

Quebec's hog industry is dominated by vertically integrated operations, and, as such, has no producer marketing agency. Prices are generally set by the province's largest packer, Cooperative Federee. Current Ontario prices are used by the packer in a formula to determine price.

Slaughtering And Processing

Records of Canada's meatpacking industry date back to 1871, when there were 193 establishments employing 841 people across the country, and producing $3.8 million in product.[29] Most of this activity was concentrated in Ontario. The number of establishments peaked in 1891 at 527. However, the industry experienced a massive consolidation and rationalization in subsequent years, primarily due to the introduction of new technology. By 1901, there were only 57 meatpacking establishments in Canada, but the value of product had risen to $22.2 million. The industry continued to grow, driven in subsequent years by the demand for pork generated by World War I, and the development of Great Britain as an export market.

In the early years, the meatpacking industry was characterized by plants four to five storeys high. Livestock were slaughtered at the top and carcasses were moved downward from floor to floor through the

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[29]Canadian Pork Council. "Pork." Ottawa. 1975. p. 10.

various processing stages until reaching the storage area at ground level.

The meatpacking industry experienced more consolidation and rationalization in recent years. The reasons for this included: low profitability of plants with excess capacity, lack of innovation, a need to modernize plants due to technological changes in slaughtering and processing techniques, and a need to consolidate and centralize operations for certain types of meat processing (e.g. sausage kitchens) as a result of the introduction of costly, highly-capitalized and automated types of processing equipment and techniques.

Today, the industry is characterized by three distinct classifications of companies: full-line slaughterers, who slaughter and process (including the kill-chill operations); non-slaughtering processors; and purveyors, who prepare cuts of meat for the hotel-restaurant-institutional trade. The remainder of this discussion focuses on the first two types of processors.

As Canada's hog production has shifted from West to East, so too has the hog packing industry. Between 1970 and 1986, the proportion of hogs slaughtered in the West declined from 42 percent to 30 percent, with 70 percent being slaughtered in the East.[30]

Currently, 23 meatpacking plants in Canada account for the majority of pork packing and processing.[31] The industry in Western Canada is comprised of eight major slaughter plants, and two processors. Most of the slaughterers are multi-species; two engage solely in hog

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[30]Agriculture Canada. "Livestock and Meat Trade Report." Various issues.
[31]United States International Trade Commission. "Conditions of Competition Between the U. S. and Canadian Live Swine and Pork Industries." USITC Publication 1615. Washington, D. C. November 1984. p. 34.

slaughter. Although B. C. has seven main packing plants, one handles most of the province's hog slaughter. In Alberta, two plants account for the bulk of hog slaughter. Saskatchewan is similar to B. C. in that one major plant does most of the hog slaughter, but a secondary pork processing plant has recently been opened in the province as well. Manitoba had five major slaughterers and processors of hogs until recently, when one plant shut down operations.

Eastern Canada has several more hog slaughtering and processing plants than does the West. Seven major firms bid for hogs in the Ontario teletype marketing system. Of these, five are major processors with their own buying machines. Two major Quebec firms plus 25 smaller ones bid for hogs by telephone through a board buying machine.

## C. THE UNITED STATES INDUSTRY

### Importance Of The Industry

Hogs have not kept pace with the rest of US agriculture over the past 36 years in generating cash receipts from farm marketings. Annual cash receipts from hog sales averaged $3.5 billion between 1950 and 1954, and nearly $9.3 billion from 1977 to 1984.[32] This 2.7-fold increase in receipts barely represented inflation over the period. Cash receipts from all farm marketings increased four-fold due to a combination of increased production and sales volumes, particularly in crops and beef cattle, and inflation.

Between 1970 and 1984, hog cash receipts increased from $4.5 billion to $9.7 billion, peaking in 1982 at $10.7 billion. This

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[32]All figures in this section are from United States Department of Agriculture "Agricultural Statistics." Various issues.

represented an increase of 116 percent. Income from all livestock sales went from $29.5 billion to $72.7 billion -- an increase of 146 percent. Finally, total farm cash receipts increased by 181 percent, from $50.5 billion to $141.8 billion.

In 1970, hog cash receipts captured nine percent of total farm cash receipts and 15 percent of livestock sales. By 1984, these shares has declined slightly to seven percent and 13 percent, respectively. Receipts from total livestock sales as a proportion of all farm sales also declined over the period, from 58 percent to 51 percent.

Structure of Swine Production

The US swine industry bears little resemblance to that of 30 years ago, when over two million farmers produced swine on small enterprises, generally together with another major enterprise. Today, the industry is characterized by a mix of small and large operations with varied levels of technology.

As in the Canadian industry, the US swine industry in recent years has experienced a trend toward fewer and larger capital-intensive operations. Greater specialization has altered the economic relationships and patterns of supply response in production. Economies of size are becoming increasingly important in determining costs and returns.

1. Historical Overview of Swine Production: Total numbers of swine on farms in the US since 1900 have remained fairly steady in most years, ranging between 50 and 60 million head.[33] However, the depression years of the 1930s saw a drop in numbers down to 30 to 40 million, while

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[33]Ibid.

inventories peaked at 84 million during World War II. In 1984, the number of swine on US farms totalled 54 million.

At the turn of the century, 4.3 million census farms (93 percent of all census farms) reported some swine. By 1959, the number of census farms reporting swine had dropped to 1.8 million, representing 50 percent of census farms. In 1978, 512,292 farms raised swine -- 21 percent of census farms.

Swine are produced in every state of the US, but production is concentrated in or near the chief grain producing regions. Historically, 18 states have accounted for over 90 percent of total US inventories. These states are grouped into two regions: North Central and Southeast.[34]

The North Central region accounted for approximately 78 percent of total US swine production in every year between 1950 and 1980.[35] Iowa and Illinois captured the majority of this production at well over a third of the total. The western states of the North Central region gained a slightly larger share of the region's total swine production compared with the eastern states. This shift in production was attributed to lower feedgrain prices and less concern with environmental pollution from production sites.[36]

The Southeast region accounted for 13 to 16 percent of total US swine inventories between 1950 and 1980. It was believed that the more favourable climate of the region, and the resulting lower pig mortality

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[34]The North Central states include: Minnesota, South Dakota, North Dakota, Kansas, Missouri, Iowa, Illinois, Indiana, Ohio, Wisconsin, and Michigan. The Southeast states include: Alabama, Georgia, South Carolina, North Carolina, Virginia, Kentucky, and Tennessee.
[35]R. Van Arsdall and K. Nelson. "U. S. Hog Industry." USDA ERS Ag. Econ. Report 511, June 1984. p. 13.
[36]Ibid. p. 4.

and higher feed conversion ratios, initiated the gradual increase.

2. Size of Operations: The swine industry in the US followed a trend in recent years toward larger-sized operations. In 1950, average swine sales per farm were 31, while in 1978 this figure rose by 532 percent to 96 head.[37]

In 1964, only seven percent of total swine sales originated from farms selling 1,000 head or more annually. By 1978, this proportion had risen to 33 percent. Farms selling 5,000 head or more reported approximately seven percent of total sales in that year. Overall, 3.3 percent of the total farms reporting swine accounted for one-third of total sales in 1978. This shift to fewer and larger operations, along with the associated changes in production methods, is likely the most important factor influencing the industry today.

Changes in the size of swine operations have not been uniform throughout the country. In the North Central region, midsize operations (sales of 200 to 2,000) dominated production in 1978, at 68 percent of total sales, and 35 percent of swine farms. Farms with sales of 5,000 head and over (0.2 percent of farms) accounted for 5.5 percent of sales.

The size distribution of swine production in the Southeast region in 1978 differed markedly from that in the North Central region. Farms with sales of less than 100 head accounted for 18 percent of sales, and 81 percent of farms, while those with sales exceeding 5,000 head (0.2 percent of farms) accounted for 15 percent of the total.

3. Types of Enterprise: As is the case in Canada, the US swine industry is comprised of farrow, farrow-to-finish, and finish operations. Some farmers maintain mixed enterprises, but the majority are involved in

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[37]Ibid. p. 5.

only one type of enterprise.

Farrow-to-finish operations have traditionally dominated swine production. In the North Central region, 59 percent of total sales in 1980 originated from this type of enterprise.[38] Farrowing operations accounted for 20 percent of sales, and finishing enterprises contributed the remaining 21 percent.

In the Southeast region, farrowing enterprises accounted for 26 percent; farrow-to-finishers, 51 percent; and finishers, 23 percent of total swine sales.

4. Type and Mix of Enterprise: In 1980, 72 percent of all types of swine enterprises in the US also raised other livestock, typically beef cattle.[39]This proportion was somewhat lower for farrowing enterprises in both the North Central and Southeast regions. On farrow-to-finish and finishing operations in both regions, 76 to 78 percent of farms reported other livestock. Between 1975 and 1980, the proportion of farms reporting swine as the only type of livestock enterprise increased by one percent annually.

Nearly all swine producers in 1980 were engaged in crop production as well.

5. Type of Farm Organization: Sole proprietorships accounted for approximately 80 percent of all swine farms in 1980.[40] General partnerships, composed primarily of family members, accounted for most of the remainder. Various corporate forms of business organizations, most of which were cooperatives and family corporations, accounted for

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[38]M. Hayenga, V. Rhodes, J. Brandt and R. Deiter. The U. S. Pork Sector: Changing Structure and Organization. Iowa State University Press. Ames, Iowa. 1985. p. 12-23.

[39] Ibid.p.3.

[40]R. Van Arsdall and K. Nelson. op. cit. p. 15.

less than five percent of all swine farms. However, farms with annual sales exceeding 1,000 head gradually moved away from the sole proprietorship form of business organization in recent years.

In terms of type of enterprise, sole proprietorships accounted for 86 and 89 percent of farrowing operations in the North Central and Southeast regions, respectively. Sole proprietorships on farrow-to-finish enterprises accounted for 81 and 80 percent of enterprises in the North Central and Southeast regions, respectively. On feeder operations, sole proprietorships accounted for 79 percent of farms in both regions. In all cases, partnerships comprised most of the remaining proportions.

## Marketing

Early in the twentieth century most hogs were slaughtered by the five largest packers in the US. These companies purchased their hogs through commission firms located on public terminal markets adjacent to their plants. Farmers typically shipped hogs by rail to the terminals where they were sold by the agents. The hogs were shipped without any knowledge of the price that would be received.

The improvement of truck transportation and highways after 1920 brought about the establishment of packing plants closer to many production centres and away from the terminal markets. Packers purchased a large proportion of hogs direct from farmers and also established buying stations in dense production areas.

Most producers preferred the advantages of selling direct to nearby packers due to lower handling and shipping costs. Prices were usually posted, leaving far less uncertainty than in terminal markets.

Producers believed that they had greater bargaining power and flexibility, and although the posted prices were often below the top prices at terminal markets, they felt that net returns were higher.

The decline in importance of terminal markets was gradual but noticeable. In the 1920s, packers procured close to 80 percent of their slaughter hogs through terminal markets, compared to 50 percent in 1940 and 14 percent in 1980.[41] Direct marketings in 1980 accounted for 75 percent of all hog packer purchases.[42] The remaining 11 percent of sales were made through auction markets. This type of market was traditionally important for smaller producers. The method of selling, however, remained the choice of the individual producer.

It has been noted that as enterprise size increases, producers are more likely to market direct to packers.[43] The large producers can ship in truckload lots and typically possess sufficient market knowledge to effectively negotiate with packer buyers. In 1980, small producers sold approximately 50 percent of their hogs direct, while large producers marketed 80 percent direct to packers.[44]

On a regional basis, direct sales are predominant in both the North Central and Southeast areas, but terminal markets rank second in importance in the North Central states, while auction markets are second in the Southeast.

The majority of hog producers in the US utilize only one type of marketing channel. However, between 10 and 20 percent of larger producers sold hogs through two types of markets during 1980.

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[41]M. Hayenga, V. Rhodes, J. Brandt, and R. Deiter. op. cit. p. 23.
[42]R. Van Arsdall and K. Nelson. op. cit. p. 34.
[43]Ibid. p. 13.
[44]Ibid. p. 10.

Slaughter hogs traditionally were sold in the US on the basis of liveweight with the buyer judging value from visual inspection. The simplicity of the procedure rendered it an attractive option for many years, but it was not considered to be highly accurate in reflecting the true value of the product. In the 1960s, packers began to offer the option of paying for hogs on the basis of carcass grade and weight determined by measurements made after slaughter. Producers, however, have been slow in accepting this method of pricing and packers have not promoted it strongly.

Currently, about 11 percent of the US slaughter hogs are priced on a carcass basis, with the remaining 89 percent still being priced on a liveweight basis.[48] Each packer has the option of using USDA standards or designing its own grade and weight system. Most packers tend to design their own system. It is felt by many in the industry that this inconsistency in standards has confused sellers and discouraged the use of carcass merit selling.

Slaughtering And Processing

In the early 1900s, the US meatpacking industry was dominated by five large firms. Several species of livestock were typically slaughtered within a multi-storey plant located at or near a terminal market. Packer branch houses in dense population centres provided a local sales outlet for retailers.

In 1920, the Federal Trade Commission undertook an investigation of the "Big Five" packers. The outcome was charges laid against the packers for collusive and anticompetitive practices. This legal action,

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[48]M. Hayenga, J. Rhodes, J. Brandt, and R. Deiter. op. cit. p. 13.

along with improved transportation equipment, roads and communication, the increased use of Federal grades for beef, and a movement in the production of livestock to the West resulted in a restructuring of the packing industry.

Improved technology in the areas of refrigeration and materials handling in the 1950s further altered the structure of the meatpacking industry. Large, single-storey plants replaced the multi-storey ones, and packers increased direct purchases from producers and shipped carcasses directly to retailers. Packers were successful in keeping labour costs low and the industry's efficiency improved.

By 1972, there were 187 hog slaughtering plants in the North Central region of the US, killing approximately two-thirds of the total US slaughter volume, and accounting for one third of all establishments.[46] The Southeast region slaughtered 18 percent of the US volume in 1972 in 189 plants, which accounted for 32 percent of establishments.

In the early 1980s, many of the hog slaughtering plants in the US were involved in wage negotiations and contract restructuring. The result of this activity was the closing and re-opening of many plants under new management; some utilized bankruptcy procedures to achieve lower wage rates; and some companies sold plants to other companies who then hired a new work force or negotiated lower wages with the unions. The end result was some consolidation and rationalization in the industry.

By 1982, the North Central region had 156 plants (33 percent of establishments) and killed 72 percent of the US volume. The Southeast

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[46]K. Nelson. "Issues and Developments in the U. S. Meatpacking Industry." USDA ERS Staff Report AGES-850502. August 1985. p. 37.

region killed 19 percent of the US volume in 139 plants (30 percent of establishments).

The number of plants slaughtering more than one million head annually increased from 23 in 1972 to 35 in 1982. The proportion of US slaughter accounted for by these large plants increased from 36 to 59 percent over these years.

Currently, the top four hog slaughtering firms in the US are Armour, Hormel, Swift Independent, and Wilson. In 1984, it was estimated that they slaughtered between 35 and 40 percent of the total US volume.[47] In 1950, the four-firm concentration ratio of the top slaughtering firms was 48 percent.

At the regional and state levels, the four-firm concentration ratios are generally much higher. In 1982, at the regional level, the top four packers accounted for anywhere between 40 percent (East North Central) and 93 percent (Pacific Coast) of volume. At the state level, this ratio ranged from 62 percent (Iowa) to 99 percent (Kansas, Indiana, Minnesota, and Nebraska).[48] It should be noted, however, that state concentration ratios usually overestimate the market influence of the large firms. For example, hogs produced in Iowa are often purchased and slaughtered in large numbers by plants in Minnesota, Wisconsin, South Dakota, Nebraska, Missouri, and Illinois.[49]

Hog slaughtering plants continue to be located closest to the large production areas, effectively minimizing freight costs. As would be expected, the plant size is also influenced by nearby availability of hogs. In very high-density areas, the most efficient plants are

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[47] Ibid. p. 27.
[48] K. Nelson. op. cit. p. 32.
[49] Ibid. p. 18.

operating two shifts with annual volumes of two to four million head.[88] In other less-densely populated regions, the increased procurement costs associated with buying hogs and hauling them long distances make smaller plants or single shifts more efficient.

D. SUMMARY

The US and Canadian pork systems can be summarized as follows:

1. Importance of the Industry: Farm cash receipts from the sale of hogs totalled Cdn. $1.8 billion in 1985 in Canada, and US $9.7 billion in the US. Hog receipts typically represent nine percent of total farm receipts in Canada, and seven percent in the US.

2. Structure of Swine Production: Swine production in both countries has moved toward larger, capital-intensive confinement enterprises. Production in Canada is concentrated in the East, while production in the US is located primarily in the North Central region.

In recent years, a greater percentage of swine sales are originating from larger enterprises.

Swine production in both countries is found on three main types of enterprise: farrow, farrow-to-finish, and finish. Farrow-to-finish enterprises dominate production both sides of the border.

The majority of swine are raised on farms with crop and other livestock enterprises in both Canada and the US.

Sole proprietorships are the dominant type of farm organization for swine production in both countries. Partnerships and corporations have accounted for a small percentage of the larger operations in recent years.

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[88]M. V. Hayenga, V. Rhodes, J. Brandt, and R. Deiter. op. cit. p. 34.

3. Marketing: In Canada, most hogs are sold compulsorily by provincial marketing boards or commissions operating central-selling agencies. Contractual arrangements comprise the remainder of hog sales.

In the US, producers have the option of selling hogs through the outlet of their choice. Direct marketings to packers are most prevalent, although terminal markets and country auction markets are also used.

4. Slaughtering and Processing: The meatpacking industry in both countries has undergone consolidation and rationalization in the 1980s. Approximately 23 plants do the bulk of hog slaughtering and processing in Canada. This activity is centred in Eastern Canada.

In the US, there are several hundred major hog slaughtering and processing plants. Activity is located mainly in the mid-west states.

## E. CONCLUDING COMMENTS

From the data reported in Chapter II and research by previous authors, some inferences can be made regarding the structure of the US and Canadian swine industries. It has been stated that swine production in both countries closely resembles the model of perfect competition (large number of participants, producers are price takers).[51] The structure of the packing industries is not so evident, however. While the industries in Eastern and Western Canada seem to exhibit an oligopsonistic structure (few buyers), the US packing industry may fall somewhere between perfect competition and oligopsony.[52] Therefore, the following chapter will contain a description of price determination under both

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[51] M. Hawkins, R. Bennett and A. Boswell. "North American Hog-Pork Study." Agriculture Canada. Ottawa, Ontario. 1972. p. 24.

[52] S. Baah. "Pricing Efficiency of Alberta Hog Industry." University of Alberta, Department of Rural Economy. Unpublished M. Sc. Thesis. Edmonton, Alberta. 1984. p. 36.

models.

# III. PRICE THEORY

## A. INTRODUCTION

Agricultural product prices have both economic and political importance. Prices, through a complex system of interrelated commodity and factor markets, are the primary directors of economic activity. On the production side, commodity prices interact with factor prices, serving to allocate scarce resources among alternative uses. Factor prices are prime determinants of income and its distribution. Income plus commodity prices serve to ration the available goods and services among consumers. It is clear that prices influence the level of farm incomes, export earnings and consumer welfare.

Agricultural commodity prices are more volatile than are prices of most non-farm goods and services. Price fluctuations create risk, uncertainty and inefficiencies for farmers and marketing agents. Supply fluctuations commensurate with this instability also have detrimental effects on efforts to expand and maintain export markets for agricultural products.

Several key causes of agricultural price instability have been identified.[33] The biological nature of agricultural production has resulted in actual output exceeding or falling short of planned output in some years. The vagaries of weather, disease and pests have also exerted negative impacts on yields in both crop and livestock production. Seasonal variations in production have contributed to price instability, although structural changes in the agriculture industry (e.g. emergence of large, confinement hog operations) have successfully

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[33] W. Tomek and K. Robinson. Agricultural Product Prices. Second Edition. Cornell University Press. New York. 1981. pp. 23-37.

tempered some of this variability.

Muth hypothesized that the expectations of farmers themselves have been a major source of price fluctuations in agricultural markets.[54] Time lags exist between the decision to produce and the realization of final output. In the hog industry, for example, at least a year is required to make noticeable alterations in production numbers. Relatively high or low prices may persist for periods of time due to the inability of farmers to respond promptly to changes in price signals.

The nature of demand for farm products has also played a role in price instability. The inelasticity of food demand has meant that price changes have a minimal impact on consumer purchases. Supply changes, then, have induced a relatively large price change for these products.

An understanding of price and pricing relationships is central to analyzing the problems facing the agriculture industry. This chapter will provide a theoretical framework in which to approach the research questions at hand. A brief review of the price determination mechanism under competitive and oligopolistic market structures will introduce the discussion, followed by a presentation of temporal and spatial components in price relationships. A description of the pricing efficiency concept as defined in industrial organization theory will complete the theoretical framework for evaluating North American hog prices and pricing relationships.

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[54] J. F. Muth. "Rational Expectations and the Theory of Price Movements," Econometrica. 29(3), July 1961. pp. 315-335.

B. PRICE DETERMINATION

The competitive structure of the economy in a particular area is pivotal in the price determination process. Price behaviour, in terms of level and frequency of change, varies with the type of market structure under study, as in the North American hog industry. Industrial organization theory suggests that a structural change toward increased buyer concentration results in the use of market power by larger buyers to depress prices paid to producers.[55] The theory posits that elements of market structure, including the degree of seller concentration and the degree of buyer concentration, directly influence firm behaviour which, in turn, ultimately determines market performance.

Connor conjectures: "Economic theory suggests that an atomistically organized sector wedged between two oligopolistic ones will pay monopolistically inflated prices for its inputs and receive relatively lower, less flexible prices for its output."[56] He goes on to say: "When there is a high level of buyer concentration in a given local market for agricultural produce, price-fixing, price leadership, price discrimination and other forms of collusive pricing are likely to occur."[57] The problems in the Alberta hog industry in the 1970s and early 1980s, documented by several court cases involving charges of anti-competitive behaviour against the small number of processors in the province, would appear to support Connor's statements.

The foregoing discussion indicates the necessity of considering price determination within the context of the market structure under

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[55] F. M. Scherer. Industrial Market Structure and Economic Performance. Rand McNally and Company. New York. 1970. pp. 45-49.
[56] J. M. Connor. "Manufacturing and Food Retailing" in Structure Issues of American Agriculture. United States Department of Agriculture, Agricultural Economics Report 438. November 1979. p. 227.
[57] Ibid. p. 15.

study. Spatial markets within the North American hog industry can be viewed as both oligopolistic and tending toward perfect competition. Therefore, the following sections will deal with price determination under the two market structures.

## Pricing Under Perfect Competition

Models of agricultural product price behaviour often assume a perfectly competitive market structure, characterized by many buyers and sellers, rational behaviour by market participants, easy entry and exit conditions, and perfect knowledge. Primary agriculture is often cited as approximating these conditions, with its large number of producing units dispersed over a wide geographic area.

Equilibrium is achieved in a market for a particular commodity when a price is established at which the quantity offered for sale by producers exactly equals the quantity demanded by consumers. If the price in the market is higher than this level, the quantity offered would exceed the quantity demanded. Competition among sellers would create instability and the price would be forced down to the equilibrium level. Likewise, prices below the equilibrium level would be unstable and would be forced up by the bidding of prospective buyers.

The major factors influencing demand include: demographics, income and prices of competing products. These factors are assumed constant for a given level of a demand function, but change over time, leading to price changes.

Shifts in the supply function are caused by several factors, such as: changes in input prices, technology or prices of joint products, and institutional constraints.

Actual market prices will approximate equilibrium prices in a purely competitive market; however, transaction prices generally deviate due to imperfect information on the part of market participants.[58] Since equilibrium prices are unobservable, it is difficult to ascertain the relationship between them and transaction prices. Theory states that under competitive conditions, transaction prices do tend to converge toward an equilibrium price.[59]

The discussion thus far has assumed that economic adjustments are made instantaneously without time lags and frictions. In reality, however, economic agents may take time to acquire knowledge and adjust to changing quantity and price situations. This is particularly true on the supply side. Hence, price determination can be viewed as several interrelated situations based on varying time lags. The length of run in supply, for example, is dictated by the fixity of production factors.

The very short-run, or market, situation is characterized by fixed plant and equipment. Supplies are given, resulting in a perfectly inelastic supply function. Alterations in production are not possible. The entire quantity is placed on the market regardless of price. On the demand side, population, incomes, prices of competing products and other demand determinants are also fixed.

The market situation is especially relevant for perishable commodities that cannot be stored. Sellers of nonperishable goods have the option of placing their supplies on the market or storing them in anticipation of higher prices at a later date. It is often assumed that the supply of slaughter hogs remains fixed for several months at a time.

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[58]R. G. Bressler, Jr. and R. A. King. Markets, Prices and Interregional Trade. John Wiley & Sons, Inc. New York. 1970. pp. 43-56.
[59]G. Stigler. The Theory of Price. Revised edition. The MacMillan Co. New York. 1952. pp. 23-27.

However, producers can withhold hogs from markets for a few days or rush them to market earlier depending upon their expectations of price movements in the short term.

Supply and demand schedules tend to become more elastic over time as adjustments to price changes take effect. A long-run price emerges under conditions in which each firm has the opportunity of modifying its production facilities, and producers can enter or exit the industry freely. The minimum points on both short-run and long-run average cost functions dictate an equilibrium condition. At this point, there are neither profits nor losses, and firms have little incentive to enter or exit the industry.

The frequency and magnitude of price changes under competitive market conditions depend on:

1. The frequency and magnitude of shifts in supply and demand.
2. The slopes (elasticities) of the function.[60]

Income or population changes will shift the demand curve; changes in prices of inputs will cause the supply function to move. Structural changes in supply and demand will alter the slopes of the curves.

Inelastic functions combined with rapid changes in supply and demand from one period to the next will cause wide price fluctuations in the short term. The inelastic demand and variable supply that typify agricultural markets exemplifies this situation.

Price changes will be minimal if the demand or supply functions are flat and do not shift substantially from one time period to the next. However, even if the demand schedule has a steep slope and shifts regularly, price changes will be minimal with an elastic supply

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[60]W. Tomek and K. Robinson. op. cit. p. 25.

schedule.

The many combinations of shifts in supply and demand and differing slopes contribute to the varying degrees of price instability between commodities.

Pricing Under Oligopoly

Oligopoly (oligopsony) markets are characterized by a small number of sellers (buyers), with either differentiated or undifferentiated products. The hog slaughtering industry in Western Canada has been cited as an example of an oligopsony market.

Interdependence among firms in a particular market is the distinguishing feature of price determination in an oligopolistic (or oligopsonistic) market. Caves postulates that "the essence of oligopoly is that firms are few enough to recognize the impact of their actions on their rivals and thus on the market as a whole."[41] The central tenet in this interdependence is that it must be recognized by market participants.

Firms operating in an oligopolistic market tend to avoid price competition because of the threat of retaliation by other firms. When one firm cuts its price, it must consider that the sales stolen from its rivals will cause them to follow suit. This element of market conduct is unique to oligopolistic industries .

In an oligopolistic market, individual firms normally set their own list prices, adjusting them to changing market conditions or to changes introduced by rivals. When the product is undifferentiated, as

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[41] R. C. Caves. American Industry: Structure, Conduct and Performance. Fifth edition. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. 1982. p. 50.

in the slaughter hog market, the adjustment and response process proceeds rapidly. Market participants are very sensitive to each other's moves, and a new market price is arrived at expediently.

Prices are set by oligopolists according to a few general rules of thumb. A normal rate of return on investment, or a standard mark-up over and above costs, may be used in price determination. The normal profit or markup will be the maximum amount a firm believes it can earn without attracting entrants. The firm also considers the expected response of its rivals to price changes.

There is no typical demand situation facing an oligopolistic firm. The interdependence of market participants makes the determination of the single seller's demand curve difficult.[63] In some situations, the demand curve faced by the firm is indeterminate. This occurs when the firm cannot predict rivals' reactions to its changes in price and output. The range of possible reactions is fairly broad. Rivals may just meet the price change; they may change price in the same direction but by less than the change of the original seller; they may exceed the price change; and they may engage in some form of non-price competition.

When a single seller knows with some accuracy how its rivals will react to price changes, the firm's demand curve becomes more determinate. The kinked demand curve is often used to explain the reactions which the oligopolist anticipates from its rivals. If one firm alone raises its price, the demand for its product will decline rapidly. The demand curve facing this firm will be very elastic. However, if all rivals in the market make corresponding price changes, the market share of the firm will remain unchanged and the demand curve will be very

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[63]R. Leftwich. The Price System and Resource Allocation. Sixth edition. The Dryden Press. Hinsdale, Illinois. 1976. pp. 15-26.

inelastic. The uncertainty a firm faces regarding rivals' response to price changes causes the demand curve to adopt a kinked, discontinuous shape. A firm would tend to alter its price only at rare intervals, when market conditions clearly called for a change. A "stickiness" is introduced into the pricing behaviour of the market.

Prices in an oligopoly market are reconciled to yield a consistent industry price through various channels. Formal agreement among sellers may extend beyond prices to include selling practices and product quality. Price leadership occurs when one firm, usually the largest, takes the lead in changing industry prices. This form of price coordination is most prevalent in oligopoly markets selling undifferentiated products. In some oligopoly markets, firms are able to determine price through tacit coordination. This is most common when the market exhibits strong product differentiation.

C. TEMPORAL PRICE RELATIONSHIPS

The preceding sections on price determination have presented conventional supply-demand theory in arriving at an equilibrium price under static market conditions. In reality, however, forces are continually at work to influence both the level and the slope of the supply and demand schedules, resulting in price changes over time. Therefore, an analysis of pricing relationships must include time elements in prices.

Persistent patterns of price behaviour through time are referred to as temporal price relationships. Prices observed through time are the result of a complex mixture of changes associated with seasonal, cyclical, trend, annual and irregular factors.

Short-term price fluctuations are caused by variations in receipts, temporary fluctuations in demand, psychological factors, and the experimentation involved in the discovery of supply and demand conditions and prices.[63] In the process of price discovery, a more or less continuous procedure of evaluation of factors influencing prices occurs. As negotiations and trades take place among buyers and sellers, specific prices are discovered. Hence, prices may change from week to week or even within the trading day.

Prices respond, in part, to current changes in economic variables. A major factor in day-to-day price changes for livestock is daily changes in market receipts. Current cash prices also may respond to expected (future) changes in factors influencing price. An example of this would be the anticipation of a strike at a packing plant that would hamper hog marketing.

Some agricultural prices are established within an institutional framework, which tends to decrease or eliminate daily price changes. Contracts are sometimes negotiated between sellers and buyers with price fixed by a formula or by prior agreement. Structural changes in agriculture toward larger, specialized enterprises are also thought to result in less frequent price changes.

The second major time element in prices involves seasonal variations. Seasonal price behaviour refers to a regularly repeating pattern that is completed once every twelve months. It might arise from seasonality in demand, in supply and marketing, or a combination of the two. An example in hog markets would be the higher demand in the summer months for pork by consumers.

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[63]G. Stigler. op. cit. p. 45.

Most agricultural products are characterized by some seasonality in production and marketing patterns. In the livestock industry, seasonality of production arises from seasonal variation in climatic conditions, seasonality of feed supplies, and the biological nature of the production process. Seasonality in demand also exists for agricultural products and is related to climate and holidays.

The usual price pattern for a seasonal commodity is for the price to rise through the year as a function of the storage costs. The price will rise from a low point at harvest by just enough to cover storage costs from the time of harvest to subsequent points in the year. The product is allocated through the year by the relationship of current price and expected prices to storage costs.

A principal factor in yearly variability of agricultural prices is changes in supply. The available supply in any one year is based primarily on current production and to some extent on imports and carryover stocks. Demand may also change, due to fluctuations in export demands, variations in prices of substitutes, and systematic changes in population and incomes.

The fourth time element in prices involves trends. These are associated with general inflation and deflation in the economy, as well as factors specific to agricultural products such as changes in consumer tastes and preferences and technological changes in production. Slow changes in supply and demand which occur over a lengthy period may cause a gradual but distinct change in prices.

Distributed lag responses may also be a factor in longer term changes in economic variables. Economic responses are not instantaneous. Given a change in price, the change in quantity supplied is lagged and

perhaps distributed through time. Therefore, a one-time increase in price could result in observed increases or decreases in quantity supplied over several years.

Cyclical behaviour is also observed in prices over time. A cycle is a pattern that repeats itself regularly over a given time period. The length of a cycle extends from one peak or trough to the next peak or trough. A true cycle is self-energizing and not the result of chance factors. Cycle-like behaviour could be initiated by an external event such as a drought, but such a "cycle" would dampen unless re-generated by another external event.

Opinions differ as to whether cycles in agriculture are of the self-generating type or are induced by outside occurrences. It is often difficult to distinguish between cyclical and random behaviour. A common view is that agricultural cycles are often initiated by external events, but these cycles would dampen unless stimulated by new shocks; the combination of systematic and random behaviour appears like a continuous cycle.

Temporal price variability for agricultural commodities can be attributed to three basic factors:

1. The biological nature of the production process which makes output partially dependent on uncertain events and creates seasonal peaks in production.
2. The prevalence of lagged response relationships in agriculture. The lag between a decision to produce and the realization of output is a function of the biological production process, and since farmers use prices prevailing at the time of the production decision, current output is influenced by past prices. Hence, cyclical changes in

output occur.

3. The price inelasticity in both supply and demand means that small changes in supply or demand can lead to large changes in prices.[64]

D. SPATIAL PRICE RELATIONSHIPS

This chapter's discussion has focused thus far on the determination of price for a particular commodity as a result of the forces of supply and demand in a single market. However, price-making forces in agriculture are often not confined to regional or national boundaries. For many commodities, as in the case of hogs, a broader scope is essential to understanding the impetus for price changes. An understanding of the direction of price adjustments between markets engaged in trade will have implications for price determination in those markets.

The principles which underlie price differences between regions (assuming a competitive market structure) are summarized as follows:

1. Price differences between any two regions that trade with each other will just equal transfer costs.
2. Price differences between any two regions that do not trade with each other will be less than or equal to transfer costs.[65]

When arbitrage occurs between regions, commodity from the lower-priced regions will be transferred to the higher-priced regions. As this occurs, the lower prices will be pushed up while the higher price declines, until prices in the regions are equalized minus transfer costs.

Using these principles, theoretical spatial price relationships, called the "structure of prices," can be determined. The structure of

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[64]W. Tomek and K. Robinson. op. cit. p. 32.
[65]Ibid. p. 15.

prices is a function of the pattern of trade and transfer costs. In the case of all surplus-producing areas shipping to one central market, the structure of prices in each surplus area will differ by the cost of transporting the commodity to the central market.

The determination of spatial price relationships becomes more complicated when there are several markets to which producers may ship their product and more than two surplus-producing areas. This situation exists in the North American hog industry. Here, the optimum pattern of trade is not intuitively obvious. Until the pattern of trade is identified, the structure of prices cannot be determined. Linear programming techniques have frequently been utilized in solving such problems.

While the general structure of prices in the absence of trade barriers generally conforms to what would be expected based on transfer costs, exceptions do exist. Price differentials may exceed transfer costs, even for extended periods of time, due to incomplete or inaccurate market intelligence, preferences on the part of buyers for produce grown in a particular area, and institutional or legal barriers to the movement of commodities between regions. Temporary factors, such as a shortage of transportation, can also lead to distortions in price differences between regions.

A change in the volume of trade or in price relationships between regions may occur whenever any regional supply or demand curve shifts, or transfer costs change.

E. PRICING EFFICIENCY

Bain defines market performance as the indicator and measurement of the contribution of firms' market activities to the general material welfare of the economy.[46] Scherer considers performance criteria as allocative efficiency of resource use, equity of income distribution, progressiveness and macroeconomic stability.[47] According to Williams and Stout, market performance is a composite of profits, levels and variations of production, costs and growth and development.[48]

Most authors agree that market performance deals with progress of the industry in developing new technology and satisfying consumer demands for new products, profits of the industry and macroeconomic goals of full employment or resource usage. As such, performance of an industry must be evaluated by specific criteria. Industrial organization theory splits performance into two components: pricing efficiency and operational efficiency. Operational efficiency refers to adjustments that individual firms make to reduce per unit costs. Pricing efficiency attempts to measure market performance of the industry in establishing equitable prices.

Williams and Stout conclude that pricing has allocative, balancing, and producing functions.[49] Pricing efficiency is concerned with such questions as how well the price system interprets changes in consumer demand, how well prices transmit demands back to producers and induce a proper allocation of resources among alternative productive uses, and how well the price system distributes income among market

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[46] J. S. Bain. Industrial Organization. John Wiley and Sons, Inc. New York. 1966. pp. 15-27.
[47] F. M. Scherer. op. cit.
[48] W. Williams and T. Stout. Economics of the Livestock-Meat Industry. MacMillan & Co. New York. 1964. pp. 34-45.
[49] Ibid. p. 15.

participants.[70] For example, if consumers express a preference for lean meat, it is presumed that competitive market forces, acting through the pricing mechanism, will transmit this message through market channels back to producers and induce an increase in production of that quality of meat. For prices to achieve these functions, pricing information must be accurately and rapidly transmitted to the buyers and sellers in the marketplace.

Williams and Stout classify perfect prices into four categories:

1. Perfect prices among geographically separated markets;
2. Perfect prices in time;
3. A single uniform price prevailing at one market at a particular point in time for a given form, grade, or class of a commodity; and
4. Price differences among forms, grades, or classes are exactly equal to the costs of converting the commodity from one such form, grade, or class to another.[71]

All markets are typically characterized by pricing inefficiencies. To consider improvements, however, some reference point or standard of measurement is necessary. The concept of the perfectly competitive market is considered by most authors (Williams and Stout; Tomek and Robinson; et. al.) to represent the ideal in pricing.

Hawkins states that pricing deviations from the concept of the perfect market price are caused by inefficiencies in the pricing mechanism and the inability of the marketing mechanism to remain responsive to the dynamic forces operating in the market.[72] Equilibrium

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[70] J. McCoy. Livestock and Meat Marketing. The AVI Publishing Company, Inc. Westport, Connecticut. 1972. pp. 56-58.
[71] W. Williams and T. Stout. op. cit. p. 23.
[72] M. Hawkins. "Alternative Methods of Marketing Livestock," Canadian Journal of Agricultural Economics. 17(3), November 1969. pp. 104-111.

prices are constantly changing in response to shifts in supply and demand. Marketing participants may be unaware of the discovery of equilibrium prices due to lack of market knowledge, the prohibitive cost of obtaining information, or they may not be aware that the information exists. These represent potential sources of pricing inefficiencies.

Most agricultural markets are characterized by pricing inefficiencies, but wide variations exist between markets. Therefore, criteria have been developed to evaluate pricing efficiency. It should be noted that the concept of pricing efficiency makes an implicit value judgement that prices which deviate from the competitive norm are undesirable.

Williams and Stout list several criteria for judging pricing efficiency:

1. More competition is generally better than less competition;
2. Restrictions to entry and exit or barriers to trade are usually considered impediments to progress. Some exceptions are justified, however, as in the case of plant and animal disease control;
3. Markets will have increased efficiency with more information than less, and all participants should be equally and uniformly informed;
4. If grades, standards and weighing procedures are carefully defined, pricing and physical handling will be more efficient;
5. Freedom from excessive government interference is preferred; and
6. The rules of the game should be explicit and enforced.[33]

One must also assume that the information was truthfully, adequately and accurately reported from the start.

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[33] W. Williams and T. Stout. op. cit. p. 26.

With regard to the necessity of information, Gupta and Mueller state that in perfectly competitive markets, information is assumed to be available at zero cost, traders are rational and fully informed, and competition is sufficient to ensure that all available relevant information is reflected in market prices.'[74] In reality, however, information is costly to obtain and rational traders acquire it up to the point where the marginal cost of acquisition equals the marginal expected benefits. The authors conclude that the cost of information is higher in less organized, decentralized markets (direct sales to packers). In addition, the cost of information involves a set-up cost. This would give larger operations a competitive edge over small ones. In agricultural markets, then, processors are likely to have better information than individual producers, giving them market power. Gupta and Mueller conjecture that the costs of information and market structure prevent market prices from fairly reflecting all available information.

A declining volume of transactions implies less, and perhaps lower quality, information.'[75] In a perfectly competitive market, a single equilibrium price exists for a given quality product at one location at a point in time. A single market transaction price, however, contains some error relative to the unknown equilibrium. Tomek hypothesizes that an increase in the number of transactions within the time period will increase available information. Conversely, as volume declines, the quantity of information declines. Assuming the average of transaction

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[74] S. Gupta and R. A. E. Mueller. "Intertemporal Pricing Efficiency in Agricultural Markets: The Case of Slaughter Hogs in West Germany," European Review of Agricultural Economics. 9(1982). pp. 25-40.

[75] W. G. Tomek. "Price Behavior on a Declining Terminal Market," American Journal of Agricultural Economics. 62, August 1980. pp. 434-444.

prices represents an estimate of the true equilibrium price, the variance of the mean of transaction prices declines as the number of transactions increases.

Pricing efficiency in a market depends on how rapidly and accurately markets evaluate pricing information, and how accurately and rapidly this information is transmitted to buyers and sellers in the market, to other markets, forward to consumers and backward to producers. An efficient market, therefore, is one in which prices freely reflect all available information.

F. SUMMARY

It has been shown in previous research that the Canadian hog prices are discovered in a larger North American market linked by trade.[76] Theory postulates that restrictions to entry and exit or barriers to trade are usually considered impediments to progress when evaluating pricing efficiency.[77] Therefore, one would expect that the imposition of the countervailing duty on Canadian hogs in April 1985 would adversely affect pricing efficiency in those markets.

The problem at hand, then, is to devise an empirical methodology that can be used to test such hypotheses. The subsequent chapter will present a review of analytic techniques previously employed by agricultural economists to measure pricing efficiency problems.

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[76]W. Adamowicz, S. Baah and M. Hawkins. "Pricing Efficiency in Hog Markets," Canadian Journal of Agricultural Economics. Volume 32, November 1984. pp. 463-477.

[77]R. G. Bressler, Jr. and R. King. op. cit. p. 34.

# IV. REVIEW OF ANALYTIC TECHNIQUES

## A. INTRODUCTION

The instability and fluctuations in agricultural commodity prices have long been of concern to participants in the agri-food sector. The volatility of prices has increased risk in the industry and rendered long-range planning difficult, particularly for primary producers. Agricultural economists have responded to these concerns by identifying sources of imperfections in the marketplace and presenting solutions to the problems.

In particular, price discovery and pricing efficiency has received considerable attention from researchers. Here, pricing efficiency has been defined as the speed with which changes in market conditions are transmitted through the marketing system and reflected in price changes. Pricing efficiency in agricultural markets can be assessed by examining the relationship between interregional prices and their movement over time. An efficient market will quickly reflect changes in other interrelated markets. The more rapid the response, the more efficient is the information flow and the pricing mechanism.

While the central constructs of pricing efficiency analysis have remained steadfast, the techniques utilized to (quantitatively) measure the relationships have changed. The current chapter presents a review and critique of quantitative techniques applied to pricing analysis in agricultural markets.

B. STRUCTURAL ECONOMETRIC MODELS

In 1981, Leavitt studied pricing efficiency in the Alberta hog market over the period 1969 to 1981.[78] His research considered, among other things, the impact of major policy changes initiated by the Alberta Pork Producers Marketing Board on pricing efficiency in the Alberta market. He used weekly slaughter hog prices from Edmonton, Winnipeg, Toronto and an average of seven US markets (US-7).

Leavitt used correlation coefficients, coefficients of determination, and differencing models to test his study hypotheses. The three techniques form an integral component of the Ordinary Least Squares (OLS) method.

Leavitt's work failed to reach any specific conclusions regarding pricing efficiency. His differencing model indicated some improvement in Alberta's pricing efficiency over the time period. However, the other techniques showed a lack of pricing efficiency. The mixed evidence led the author to conclude that firm statements regarding pricing efficiency in the Alberta hog market could not be made.

There would appear to be several problems inherent in utilizing OLS models to measure pricing efficiency. Results obtained from correlation coefficients may be misleading. A high correlation may imply an efficient market, but it does not in any way establish causality between variables. According to Pierce and Haugh, "high correlation among variables does not in any necessary sense establish that they are causally related. Variables may be functionally related, yet be uncorrelated, and...they may be correlated yet not causally related."[79]

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[78] S. Leavitt. "Market Performance of the Alberta Pork Board." University of Alberta, Department of Rural Economy. Unpublished M. Sc. thesis. 1981. pp. 35-47.

[79] D. Pierce and L. Haugh. "Causality in Temporal Systems," Journal of

The former effect arises because correlation is a measure of linear association only, while the latter case may exist due to a common association of each with additional factors.

The second method employed by Leavitt -- coefficients of determination -- may establish causality. However, results from these models may also be misleading when applied to time series analysis. Ordinary Least Squares assumes no correlation between the random terms. But in time series analysis, economic conditions are such that previous economic values often affect present ones. For example, the price of hogs this week is likely to be influenced by hog prices in preceding weeks. In this case, using OLS could bias the standard errors of the parameter estimates.

In general, structural models offer a static approach to analyzing pricing efficiency. These models assume that prices adjust to exogenous shocks within the observation period. In reality, price adjustments typically last more than one period (a more thorough discussion of this concept is found in the Price Theory chapter). Static models of price formation are consequently no longer appropriate. Dynamic models are necessary to reflect the influence of uncertainty on price information after a shift in supply and/or demand.

The problems associated with the use of structural models for time series analysis led researchers to develop modelling techniques specifically designed for this purpose. The following two sections will discuss selected recent agricultural marketing research in this area.

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''(cont'd) Econometrics. Volume 5, 1977. pp. 265-292.

C. UNIVARIATE TIME SERIES MODELS

The concept of "Granger causality" has been incorporated into time series modelling to investigate temporal orderings between related economic variables. Granger's definition of causality essentially states that X causes Y if present Y can be better predicted by using past values of X, other relevant information (including the past values of Y) being used in either case.[88] Causality tests can determine three major patterns in temporal orderings: one way causality, instantaneous causality, and feedback. Knowledge of the lead-lag structure of various economic time series can then be used to assess pricing efficiency in the markets under study. A more thorough discussion of Granger causality can be found in Pierce and Haugh.

Univariate residual cross-correlation analysis is one time series technique frequently used to study temporal structures in agricultural markets. Autoregressive Integrated Moving Average (ARIMA) models are first fitted to the data to provide a filter for the autocorrelated structure of the time series. ARIMA filters are identified by the structure of the autocorrelation function and the partial autocorrelation function. Parameters of the models are estimated by non-linear least squares. The residuals (or white noise terms) remaining after the autoregressive and moving average effects are removed contain all other effects not associated with past values of the series. The residuals are then cross-correlated to determine the temporal structure.

Univariate residual cross-correlation analysis possesses many advantages over structural econometric models in the assessment of pricing relationships. First, several authors (Sims, Bessler, Pierce and

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[88]Ibid. p. 270.

Haugh) have noted that there is little theoretical justification for the specific lag structure often imposed a priori on data. The univariate methodology does not impose a specific lag structure. The time series data themselves are used to assess the relationship.

Second, this approach avoids the testing problems encountered when autocorrelated time series are cross-correlated. Similarly, the current approach may be used to circumvent the spurious regression problems that would likely be encountered in regressions of Y on leading and/or lagged values of X. Spurious regression (the overestimation of the significance of both the whole regression and individual regression coefficients) may be found when autocorrelated time series are regressed on each other. The significance tests (t and F) obtained from relating levels of highly autocorrelated series can be overestimated, leading to an assertion of a causal relationship when none may exist.

Miller implemented the univariate technique to analyze lead-lag relationships between beef price changes at the retail, wholesale and farm levels.[81] He used first differences of weekly retail, wholesale and net farm beef values over a four year period. Miller's results indicated that farm level changes were reflected in wholesale changes within one week, and wholesale changes were transmitted to retail values within three weeks. The author concluded that the current price discovery mechanisms in the beef marketing chain provided fairly rapid price adjustments between the three levels.

MacArthur, Hawkins, Adamowicz and Norby also used univariate analysis to assess the lead-lag relationships between Canadian farmgate,

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[81]S. E. Miller. "Univariate Residual Cross-Correlation Analysis: An Application to Beef Prices," North Central Journal of Agricultural Economics. Volume 1, July 1979. pp. 141-146.

wholesale and retail beef and pork prices.[82] They studied weekly prices in various markets across Canada. The authors found that both the beef and pork marketing channels were characterized by farm prices leading retail prices by about three weeks.

MacArthur et. al. also tested horizontal pricing relationships between markets at the same level of the marketing chain. In both the beef and pork sectors, at the farmgate level, the Ontario price led the Alberta price. At the retail level, in the beef sector, Vancouver, Calgary and Edmonton showed an instantaneous relationship, and these markets led Toronto. The Toronto retail price led the Montreal price by about one week.

Beaton and Pearson analyzed the structure of slaughter hog prices between the US-7 and four major Canadian markets.[83] They used weekly slaughter hog prices over the time period 1973 to 1980. The authors initially determined through simple correlation that the price data suggested a close relationship. This would imply that price information was communicated relatively rapidly among the study markets.

The authors noted, however, that results of this type of analysis may be misleading due to the time series properties of the data. They then applied univariate analysis to the series under study. Results indicated that in all markets, slaughter hog prices were most highly related at zero lag, implying that market information was communicated efficiently between markets. Canadian markets were more highly

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[82] J. MacArthur, M. Hawkins, W. Adamowicz and R. Norby. "New Found Relevance of Live Market Information," Canadian Journal of Agricultural Economics. Volume 33, November 1985. pp. 1-29.

[83] N. Beaton and C. Pearson. "Lead-lag Structure of Slaughter Hog Prices Between United States Midwest and Four Major Canadian Markets Utilizing Univariate Residual Cross-Correlation Technique." Paper presented at AAEA and WAE Annual Meeting, Utah State University. August 1-4, 1982. pp. 1-15.

correlated with each other than with the US market. Within Canada, Toronto prices were most highly correlated with Edmonton prices.

Pricing efficiency in Canadian hog markets was further scrutinized in 1984 by Adamowicz, Baah and Hawkins, who used weekly prices for Edmonton, Toronto and the US-7 average.[84] The price series were analyzed over six time periods corresponding to major policy changes by the Alberta Pork Producers Marketing Board. The authors utilized both an ARIMA model and the Geweke method to identify the lead-lag structure.

The Geweke technique employs OLS to estimate restricted and unrestricted models of the time series. The standard F-test for restrictions is used to compare the two models and hence determine whether past values of one variable affect another variable.

The authors determined that high levels of pricing efficiency, in terms of information flow, were evident in the first two periods. The following three periods were characterized by a decline in the information flow between markets, or, in fact an isolation of individual markets. The final period of the study indicated a return to less isolated markets.

The authors also noted that two types of pricing efficiency were at work, namely local pricing efficiency and international pricing efficiency. The empirical results indicated that North American hog markets became more isolated in the previous ten years. The authors also reported that the ARIMA and Geweke tests did not provide identical results and one should therefore exercise caution in the choice of models and test statistics.

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[84]W. Adamowicz, S. Baah and M. Hawkins. op. cit. p. 470.

Causality in livestock markets was studied by Bessler and Brandt, utilizing three methodologies: two prefiltering methods (ARIMA and Sims filters), and the Geweke method, which does not use a prefilter.[11] While the ARIMA method develops a separate filter for each time series, the Sims method incorporates a single general filter for the total model.

The authors applied the three techniques to quarterly data from cattle and hog markets. The variables included: price, slaughter quantity, sow farrowings, cattle on feed, and disposable income. The investigation was conducted to determine the nature of causality between the sets of variables and the length of the lead-lag period in these relationships.

Results showed that strongest one-way causality flowed from sow farrowings to hog prices. One-way causality with feedback was shown to occur between cattle prices and cattle on feed. Instantaneous causality was strong between the price and slaughter series of both commodities. Income and prices exhibited an instantaneous causal relationship.

In their conclusions, the authors suggested that the single filter proposed by Sims for all time series in the model was inadequate, because severe autocorrelation of the residuals remained. Tests based on prefiltering using separate ARIMA filters, and Geweke's direct tests, produced consistent results, however.

In 1980, Bessler and Schrader analyzed the relationship between price quotes for eggs from two private reporting agencies.[12] Motivation for the authors' work stemmed from the apparent inconsistencies found

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[11]D. Bessler and J. Brandt. "Causality Tests in Livestock Markets," American Journal of Agricultural Economics. Volume 64, February 1982. pp. 140-144.

[12]D. Bessler and L. Schrader. "Relationship Between Two Price Quotes for Eggs," American Journal of Agricultural Economics. Volume 62, November 1980. pp. 766-771.

between information sets used by the two agencies to determine their price quotes. One agency based its quotations primarily on information from a thinly traded cash market. The second agency used the cash market plus additional market intelligence from industry sources to establish egg price quotes.

The two series were modelled as a second order autoregressive process. The residuals were then cross-correlated. The results indicated that the first agency's price quotations led the second one by two weeks. The authors concluded that the additional information incorporated into the second price quote did not improve its power as an indicator of changes in the unobserved equilibrium price.

The current section has presented a review of pricing efficiency research utilizing the univariate residual cross-correlation technique. The attributes of this procedure were cited as: the data is allowed to suggest the nature of the causal relationship, rather than a priori reasoning; and use of the residuals rather than the original series in the cross-correlation analysis corrects the problems introduced by autocorrelation.

Univariate residual cross-correlation analysis deals with many of the problems associated with employing structural econometric models in pricing analysis. However, these models cannot be used effectively to explore causal relationships among three or more variables. Researchers have thus turned to developing multivariate time series modelling techniques as a means to measure lead-lag structures. The following section of the Chapter will present recent findings of multivariate time series analysis applied to agricultural markets.

D. MULTIVARIATE TIME SERIES MODELS

When studying agricultural markets and their interrelationships, it is often useful and more insightful to incorporate three or more time series into the analysis. Vector autoregression (VAR) models have surfaced in recent years in answer to these needs.

A VAR model is essentially a system of equations whose dependent variables are regressed on lagged observations of all the variables in the system. The autoregressive equations are first estimated, and then a moving average transformation of the model is calculated. Innovation accounting analysis is applied to the moving average representation to test the study hypotheses.

The innovation accounting analysis of VAR models provides a general method of evaluating dynamic interrelationships among time series data. The Granger-type causality tests presented in the previous section allow the researcher to indicate the presence of a predictive relationship. These tests do not permit the determination of "strength-of-relationship" type statements at alternative lags. Innovation accounting, however, allows the researcher to partition the uncertainty in each series to past shocks in itself and to other series in the model. This procedure results in a more complete dynamic analysis of price interrelationships. A thorough description of VAR modelling is presented in Chapter V.

The VAR methodology possesses the dynamic characteristics of univariate analysis. Using this type of model for lead-lag structure would seem to be the ultimate theoretically, as potentially all of the major influences on each series can be filtered out.[87] The remaining

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[87]W. Adamowicz. "Methods of Testing for Lead Lag Structure with Special Emphasis on Statistical Analysis." University of Alberta, Department of

error terms will then provide considerable insight into the lead-lag structure of the series under study. In addition, innovation accounting analysis allows the researcher to trace the isolated effect of a change to a particular component of the residuals.

Schrader, Bessler and Preston used a VAR model to evaluate alternative price quotes for eggs.[88] Their work was a continuation of the authors' earlier evaluation of egg price quotes, where univariate residual cross-correlation analysis was utilized.

In the current research, Schrader et. al. included a third price series in the analysis. The need to deal with more than two series simultaneously, and the impact of contemporaneous relationships, prompted the authors to use a VAR model in their analysis.

The authors found that a significant change had occurred in the structure of egg price quotes over the study period. A reduction in the influence of the first reporting agency quotes on the two remaining quotes at long lags was observed. The authors felt that this perhaps reflected both a shift in the pattern of trading and a fairly continuous increase in transport costs which allowed for more independent price movements in the Midwest and Northeast.

Bessler also used the VAR technique, to analyze dynamic relationships in the US hog market.[89] Quarterly data for 1958 to 1981 on hog prices, sow farrowings, hog slaughter, corn prices and disposable income were studied in a VAR. These variables were chosen because they represented biological and economic relationships in the hog sector.

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[87](cont'd) Rural Economy. Unpublished paper. pp. 1-16.
[88]L. Schrader, D. Bessler and W. Preston. "Egg Prices Revisited," Southern Journal of Agricultural Economics. December 1985. pp. 215-219.
[89]D. Bessler. "An Analysis of Dynamic Economic Relationships: An Application to the U. S. Hog Market," Canadian Journal of Agricultural Economics. Volume 32, March 1984. pp. 109-124.

A VAR was estimated on the five-variable system, along with a constant and a time trend. A lag of six quarters was used.

The VAR was then triangularized in the following order: income, sow farrowings, corn price, slaughter, and hog price. The moving average representation was computed, and the innovation accounting techniques were applied.

The authors found that hog prices and sow farrowings responded to shocks in hog slaughter, corn price, disposable income, hog prices and sow farrowings. A shock to corn prices led to higher hog prices immediately and for the near future, a shock to sow farrowings lead to lower hog prices, a shock to slaughter led to lower hog prices, and a shock to income caused higher hog prices.

Brandt and Bessler also studied US hog prices in a VAR model.[**] The authors were primarily interested in testing the forecasting ability of a VAR model.

Hog prices, sow farrowings, corn prices, slaughter cattle prices and disposable income were included in the five-variable system. The number of sow farrowings was considered to be biologically related to hog price movements. The price of corn, price of slaughter cattle and disposable income were all considered to be economic variables related through supply costs or demand shifters.

The VAR model was fit over the 1960 to 1975 period. Those factors found to affect hog prices included: a three-quarter lag of its own series, three and four quarter lags in the sows farrowing series, and one and three quarter lags in income. Neither corn prices nor cattle

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**J. Brandt and D. Bessler. "Vector Autoregressions on U. S. Hog Prices," in Applied Commodity Price Analysis, Forecasting and Market Risk Management. Proceedings of the NCR-134 Conference, Des Moines, Iowa, April 28-29, 1983. pp. 1-11.

prices were found to be important factors in hog price movements.

Quarterly cash price forecasts for hogs were then generated over the seven-year period, 1976 to 1982. Forecasts were done using both a VAR model and an ARIMA model. The authors also included a qualitative forecast based on "expert judgment."

Based on the three alternative performance evaluations, the VAR forecasting approach did not measure up to the ARIMA model or the expert judgment. The authors concluded that these results were not surprising in light of the warnings provided by earlier research regarding the use of VARs for hypothesis testing rather than for economic forecasting. However, the authors closed by stating that the VAR approach allowed the researcher to study the dynamic interrelationships between time series directly.

## E. SUMMARY

Chapter IV has presented several analytic techniques employed to measure pricing efficiency in agricultural markets. The most current technique -- vector autoregression -- would seem to offer the most potential for assessing the study hypotheses identified in Chapter I. Vector autoregression offers the advantages of incorporating several time series which seem theoretically "correct" for inclusion in a model, yet at the same time allowing the data themselves to determine the explicit dynamic (lead-lag) relationships between the series. The author wishes to raise a note of caution, however. While VAR has become widely used in economic research recently, it is often criticized for its "loose" use of economic theory. One should therefore consider the research objectives and the advantages and disadvantages associated with relevant

alternative analytic techniques before undertaking the study. In the case of the current research, it is noted that univariate models are by definition limited to a single time series. Structural econometric models have the dynamic (lagged) relationships of the explanatory variables to the dependent variable arbitrarily assigned by the researcher during the specification phase (prior to the estimation process). Thus, the analysis will proceed utilizing VAR modelling. Chapter V contains a discussion of the technique as it is applied to North American hog price relationships.

# V. METHODOLOGY

## A. INTRODUCTION

Chapter V covers the methodology employed in the empirical analysis of the study hypotheses. It begins with a discussion of the background on vector autoregression, followed by a description of technical aspects of the method. The methodology used in VAR analysis is then discussed, and finally the data sources are identified.

## B. BACKGROUND NOTES ON VECTOR AUTOREGRESSION

Applied multiple time series research in recent years has led to a new approach for conducting econometric analysis of time-ordered aggregate data known as "vector autoregression" (VAR). A VAR is designed explicitly to characterize a dynamic system without a priori forcing particular patterns of interactions among a set of variables. It is essentially a system of equations whose dependent variables are regressed on lagged observations of all the variables in the system. Exogenous or deterministic variables believed to be important can also be included in the system, but would not appear as regressands.

Identification of a VAR is achieved by estimating reduced-form relationships in which every variable may influence every other variable in the system with lags. The derived set of equations is similar to what might result from a structural econometric model based on economic theory. However, structural models enforce restrictive assumptions related to exclusion of variables or lags of variables on the values of the estimated parameters in their reduced form equations. The estimated parameters of these variables or lags excluded from the system are

restricted to zero, implying that they have no predictive or explanatory power in the model. A VAR, on the other hand, will include some of these variables, relying on a much less restrictive concept of economic theory as it applies to the reduced form equations. Economic theory is used "weakly" to suggest which variables should be included in the system. The data, rather than a priori economic structure, are then permitted to determine the contribution of variables and describe regularities in the economic relationship under study.

A VAR offers the advantages of incorporating several time series which seem theoretically appropriate for inclusion in a model yet at the same time allows the data to determine the explicit (lead-lag) relationsips between the series. By comparison, univariate models are by definition limited to a single time series. Structural models have the dynamic lagged relationships of the explanatory variables to the dependent variables arbitrarily assigned by the researcher in the specification phase. It is recognized that the channels of influence of a variable on an economic system may be many and varied, and a VAR therefore addresses the impact of a variable on all other variables. A VAR system allows the researcher to study the dynamic relationships between time series directly.

A complete discussion on the theoretical bases of VARs is found in Sim's pioneering article on the topic. He states that the dynamic nature of economic models weakens the legitimate basis for generating identifying restrictions on the model. Sims labels these structural models "incredible" or overly-identified.'[1] He also posits that a sound treatment of expectations formation in the modelling process will likely

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'[1] C. A. Sims. "Macroeconomics and Reality," Econometrica, Volume 48,

undermine many exclusionary restrictions formerly considered reliable.

Expectations formation has become a central issue in macroeconomics. Traditionally, the adoption of various ad hoc assumptions about the expectations formation process has allowed the development of simple models whose dynamic properties may be analyzed. These ad hoc assumptions have often been criticized, however, for their arbitrariness.

The recent work on the rational expectations hypothesis has been cited as an improvement in expectations formation. The rational expectations hypothesis states that individuals do not make systematic mistakes in forecasting the future; they learn from their errors. This does not imply that individuals always forecast perfectly accurately when some random movements are inevitable; rather, the assertion is that forecasts about the future must be correct on average if economic agents are to remain satisfied with their methods of expectations formation.

Muth's rational expectations model evolves from several hypotheses regarding individual behaviour, including:

1. Information is scarce, and the economic system generally does not waste it.
2. The way expectations are formed depends specifically on the structure of the relevant system describing the economy."[2]

The central tenet in Muth's work is that expectations of economic agents are based on any and all relevant information. The economic agent's decision making changes as additions are made to the information set.

In cases such as agricultural supply, where expectations of economic agents are a prime consideration, it is often not certain what

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information set (variables and lags) ought to be used in practice. It would appear, then, that in market studies, demand-side and supply-side variables may not always be clearly classified. Economic agents who are usually considered to be demanders may periodically look at and act on information related to supply. Sims poses an example of this by describing US coffee purchasers' reaction to news of a killing frost in Brazil.'[3] The weather factor would generally be considered a supply-function variable; however, consumers may stockpile coffee in anticipation of the frost's effect on coffee prices. The weather variable then enters the demand function. This example is consistent with the rational expectations model, stating that economic agents utilize all available information in their decision-making.

Several other theories have been offered to explain the expectations formation process. However, it would appear that the rational expectations model is more consistent with underlying behaviour of economic agents. The ability of variables known to affect supply to enter the demand equation, and vice versa, through terms in expected price, eliminates some weaknesses inherent in other theories.

Vector autoregression has been introduced as an approach to statistical analysis of dynamic economic systems that allows for rational expectations by not using the usual a priori restrictions. Expectations for all variables are generated within the model, taking advantage of any dynamic relationships that may exist among variables. Sims concludes that the VAR method answers the general equilibrium (or rational expectations) criticism of traditional structural models.

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## C. UNRESTRICTED VECTOR AUTOREGRESSIONS

### Background

A VAR is basically a system of equations whose dependent variables are regressed on lagged observations of all the variables in the system.

The form of a VAR originates from the Wold Decomposition Theorem and the ability to model a moving average representative of a covariance stationary process with autoregression techniques.'[4] The Theorem shows how a stationary time series can be decomposed into two parts -- a linear process and one which can be predicted exactly from at most an infinite past of a realization of the process (and is deterministic).'[5] Stated simply, any stochastic stationary process can be represented by the sum of deterministic and nondeterministic terms. The nondeterministic term is represented as a moving average (MA).

Time series data used in VAR estimation are assumed to represent a covariance stationary stochastic process. A vector stochastic process is stationary if the process has a mean and variance that do not change over time, and the covariance between values on the process at two points in time depends solely on the distance between those two points in time, and not on time itself. The stationarity assumption infers that the generating mechanism of the process is itself time-invariant -- neither the form nor the parameter values of the generation procedure change through time.

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'[4]S. Ford. "A Beginner's Guide to Vector Autoregression." Department of Agricultural and Applied Economics, University of Minnesota. Staff Paper P86-28, September 1986. pp. 1-35.

'[5]M. Nerlove, D. Grether, and J. Carvalho. Analysis of Economic Time Series: A Synthesis. Academic Press, Inc. New York, U. S. A. 1979. p. 54.

Empirical data, however, often exhibit seasonality, indicating that such raw data do not meet the stationarity assumption. In the VAR methodology, the usual procedure in this situation is to transform the data. Logs can be taken of the data, or seasonal dummies or a time trend as right-hand side (RHS) variables may be included to derive a data set represented by a stationary stochastic process.

The theory of stationary stochastic processes states that a covariance-stationary stochastic process that is linear and regular and that has m components and a mean of zero, X=(Xt), has a moving average representation written as:

$$y_t = X_t B + \sum_{s=0}^{\infty} A_s u_{t-s}$$

where $y_t$ is an M-variate stochastic process; $X_t B$ is the deterministic part of $y_t$; $u_t$ is an N-variate vector white noise process if t≠s; and $u_t$ and $u_s$ are uncorrelated. U is called an "innovation process" for y.

The moving average representation states that the level of each time series can be obtained by tracking current and past residuals in each time series. The residual vectors can be viewed as the fundamental building blocks of a vector time series. All statistical analysis can then be conducted on these vectors. However, first one must estimate an autoregressive (AR) representation. These equations involve an infinite lag of past X's. As a practical matter in estimating a VAR model, it is assumed that an infinite-lagged AR representation can be approximated by a finite lag model. An important first step in the model-building process then is choosing the appropriate lag length.

Choice Of Lag Length In A VAR

The choice of a suitable lag length is an important first step in the specification of a VAR model. A particular lag structure states that lags from any longer period do not add information to the model and have parameter values of zero. Lag length must be of a magnitude that is small enough to be operational yet large enough to yield white noise residuals. Longer lags increase the number of estimated parameters, reduce degrees of freedom, and increase data requirements.

Several criteria are suggested in the literature for choosing an appropriate lag length. First, there is an intuitive argument that regularities in economic data may be missed by using less than an annual lag structure such as four quarters or 12 months depending on the frequency of observations.''

Sims recommends using a likelihood ratio between models of different lag lengths.'' The asymptotic chi-square distribution of the log likelihood ratio can be used to test the null hypothesis of zero sum of coefficients on terms excluded from the constrained model. Asymptotically, under a null hypothesis, the omitted lags from the constrained model will have zero coefficients. The ratio is of the form:

$$(T-C)\ [\log \det \Sigma_1 - \log \det \Sigma_2]$$

where T is the number of observations; C is a correction factor to bring the test statistic closer to its asymptotic distribution; and $\Sigma_1$ and $\Sigma_2$ are the two covariance matrices.

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'' T. A. Sanni. "Vector Autoregression on Nigerian Money and Agricultural Aggregates," Canadian Journal of Agricultural Economics. 34, March 1986. pp. 67-85.

''C. A. Sims. op. cit.

A third approach to determining lags is that of choosing the length to minimize the Akaike Information Criterion (AIC):

$$AIC = (T-p)\ \ln \sigma^2 + 2p$$

where T is the number of observations; p is the number of estimated parameters; and $\sigma^2$ is an estimate of the residual variance.[88] This criterion functions in a similar manner to the adjusted R-square statistic. As the number of estimated parameters increases, $\sigma^2$ and the first term in parentheses decline, while the 2p term increases. Consequently, the inclusion of additional parameters may increase the AIC in some cases as a reduction in residual variance is out-weighted by the increase in the number of parameters.

Following model specification, the VAR can then be estimated. The VAR methodology for estimating the MA representation of a vector stochastic process involves first estimating the coefficients of the AR representation and then computing MA coefficients from the estimates.

The parameters of the unrestricted VAR are estimated by Ordinary Least Squares. This procedure is justified, given that VAR equations contain the same set of variables on the right hand side. OLS gives estimates which are consistent and asymptotically normally distributed.

Innovation Accounting Techniques

An analysis of an economic system could be based on the estimated autoregressive equations. However, the autoregressive parameters explain only the evolution of variables through time given past values of the variables. Determining movements of the dependent variable with

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[88] S. Ford. op. cit. p. 24.

exogenous changes in an independent variable is not readily accomplished. An approach to VAR modelling that would generate more useful information is to distinguish between the expected evolution of the economy (represented in the AR parameters) and deviations that occur over time as a result of unexpected shocks to specific variables. These "innovations" or residuals can be defined as "that part of the current value that cannot be explained on the basis of past values."''

The estimated autoregressive equations must therefore be transformed to derive a moving average representation of the VAR model. The transformation can be viewed as the result of a sequence of substitutions in which lagged values of RHS variables are replaced by their own autoregressive equation. Each substitution backdates the values of actual variables that appear in the initial equation by one time period and introduces errors from an additional lag.

The MA representation of a VAR places the focus of analysis on the error terms associated with the AR equations. It offers two major advantages as a basis for analysis compared to the AR equations.

First, the effects of any unexpected shock to the system can be traced through deviations of the shocked time paths from the expected time paths given by the model. This process is known as "impulse response analysis." It is useful in analyzing dynamic interrelationships among variables in the model. The impulse response function simulates over time the effect of a shock in one series on itself and on the other series of the system. For example, in a model of the hog sector, it may be used to predict the response of hog prices if the price of corn increases due to some force outside the model. If one is interested in

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'' M. Nerlove, D. Grether, and J. Carvalho. op. cit. p. 34.

the response of a system to a shock in a particular series, then all X's and error terms except the particular shock under study can be set equal to zero. A period-by-period simulation can be carried out indefinitely to plot the response of the variables in the model to a shock in a particular time series. Each variable's response is scaled by the standard deviation of the variable's innovations.

The second advantage of the MA representation is the ability to conduct forecast error decompositions. This procedure decomposes the observed variance in the "unpredictable" part of y into the parts due to the shocks to each variable in the system. Future values of the variables are forecast assuming future shocks are zero. Since these shocks are random, the variance of these forecasts can be computed. The percentage of the variance in forecasts attributable to each variable can then be determined from the variance of its shocks (estimated by the variance of the error terms of the AR equations) and the impact of these shocks on the forecasts (estimated by the MA coefficients).

Error decomposition provides an alternative to the usual tests of Granger causality. Granger causality is often used to evaluate causal relationships among variables in agricultural markets (MacArthur, Hawkins, Adamowicz and Norby; Bessler and Brandt; Beaton and Pearson; Miller; Adamowicz, Baah and Hawkins). While Granger causality is defined strictly in terms of the difference in forecast error variance with and without a particular series in a given information set, error decompositions are defined in terms of forecast error variance with the full information set. In other words, the Granger-type causality tests allow the researcher to state whether a predictive relationship exists in the data or not. These tests do not, however, allow

"strength-of-relationship" type statements to be made. Error decompositions allow the researcher to partition the uncertainty in each series to past shocks in itself or to other series being studied. The strength of explanation of different forecast horizons can be measured, providing dynamic information not previously obtainable.

Orthogonal Ordering

Simulating the response of a VAR to unit shocks in a particular innovation can be misleading if the historical data exhibit a contemporaneous correlation among innovations in each series. In addition, it is impossible to conduct any error decompositions under these circumstances. In cases where the covariance matrix of the error terms is not diagnoal, the innovation vector must undergo an orthogonalizing transformation such that the variance of the transformed innovations will be identity. The orthogonalized innovations are then uncorrelated both across time and across equations.

Orthogonalized innovations have two principal advantages over non-orthogonalized ones. First, because they are uncorrelated, it is relatively simple to compute the variances of linear combinations of them. In addition, it can be misleading to refer to a shock to a single variable in isolation when historically it has always moved together with several other variables. Orthogonalization takes this into account.

The standard orthogonalization method used is the Choleski decomposition. The variables are ordered in the system depending upon the study questions and the structure of the covariance matrix of residuals. Variables that are not expected to have any predictive value for other variables are placed last; for example, local variables in a

model with national variables would be last.

If there is little correlation between the residuals of a variable and the residuals of variables that appear before it in the ordering, the first step variance will be nearly 100 percent due to own innovations. By definition, the first variable in the ordering explains all of its one step variance. In cases where high correlation among innovations exists, decomposition of one step variance relies heavily on the order of factorization.

To determine whether a variable behaves exogenously, one can place the variable first in the ordering. The variance in an exogenous variable will be explained primarily by own innovations. The degree of "own explanation" depends upon the number of variables in the system; 50 percent is relatively high in a six variable system. When residuals are close to being uncorrelated, the order of factorization makes little difference since little variance is explained by other variables.

Innovation accounting analysis can be influenced by the ordering of the variables. The degree of influence, however, is governed in part by the extent of contemporaneous correlation present in the system. When contemporaneous correlation is relatively small, a degree of arbitrariness that a particular ordering introduces into the results will not be serious. Given that contemporaneous correlation may be relatively high, the researcher should rely on a priori knowledge in selecting the ordering. Where economic theory in informative on instantaneous correlation, it can be used.

When studying agricultural markets, knowledge of biological lags in supply production and the relative size and make-up of particular markets is useful in the ordering process. For example, in a quarterly

model of the hog sector, hog slaughter is ordered higher than is hog price. It is much more difficult to bring forth additional quantities of hogs in response to a price shock in the current period than it is for price to adjust to greater quantities of hogs.[100] This ordering may not hold, however, when regional or local markets are studied over a shorter time interval. Hogs may come forth from other markets, and if local markets are not efficient in transferring price information, the ordering of hog slaughter above hog price is open to criticism. In this case, knowledge of market competition and other structural aspects of the local market can be used in the ordering process.

Summary

To summarize the preceding sections, a VAR model provides the basis for several types of economic analysis:

1. Provides information: should specific events (shocks) occur in the economy, the likely outcomes can be determined from the moving average representation coefficients.
2. Provides a basis for discriminating among theories: alternative views can be compared to determine how closely their implications match the observed dynamics.
3. Provides a basis for evaluating sources of instability during specific historical periods. Projected values of a variable can be computed assuming no shocks occur from a particular point in time onward, then deviations from the projection can be attributed to various actual shocks and their cumulative impacts.[101]

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[100]D. A. Bessler. op. cit. pp. 109-124.

[101]D. Orden. "Money and Agriculture: A Dynamic Analysis of Relationships Among the Money Supply, Financial Asset Prices, Inflation, and Agricultural Prices and Trade." Virginia Polytechnic Institute and State

## D. VAR ON NORTH AMERICAN HOG PRICES

### Data

To implement the VAR modelling techniques and test procedures described in the previous sections, suitable variables were first chosen for inclusion in the model. The choices were based on the study objectives. The research was primarily concerned with hog price relationships in the North American market and trade patterns and linkages.

The following variables were identified as relevant to the study objectives: prices, hog exports, pork exports, and pork imports. All variables represented linkages with slaughter hog markets and the trade flows between the two countries. Table V-1 includes a listing of the variables, the mnemonics that will be referred to in the remainder of the study, and the sources of data. A dummy variable was also included in the model to account for a major strike at one of Alberta's two packing plants in 1986.

The time period to be studied was chosen as 1982 to 1986. It was decided to use weekly rather than monthly or quarterly data, in order to capture as much of the fluctuations in price movements as possible. Using the longer timeframes would exclude much of the variability experienced by hog prices.

For purposes of modelling, the North American hog market was divided into three distinct supply regions: Eastern Canada, Western Canada, and the US midwest states (represented by an average of seven states). The reasons for this division can be reviewed in Chapter II.

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[101](cont'd) University, Blacksburg, Virginia. November 1985. pp. 1-25. (mimeographed).

Table V.1 Variables, Mnemonics And Sources Of Data

| Variable | Mnemonic | Source |
|---|---|---|
| W. Canada Live Hog Exports | WHX | Canada Livestock and Meat Trade Report |
| E. Canada Live Hog Exports | EHX | Canada Livestock and Meat Trade Report |
| W. Canada Prices | WP | Alberta Pork Producers Marketing Board |
| E. Canada Prices | EP | Alberta Pork Producers Marketing Board |
| U.S. Prices | USP | Alberta Pork Producers Marketing Board |
| W. Canada Pork Exports | WPX | Canada Livestock and Meat Trade Report; Ag. Canada |
| E. Canada Pork Exports | EPX | Canada Livestock and Meat Trade Report; Ag. Canada |
| W. Canada Pork Imports | WPI | Canada Livestock and Meat Trade Report; Ag. Canada |
| E. Canada Pork Imports | EPI | Canada Livestock and Meat Trade Report; Ag. Canada |

Data representing the variables were not always reported in a form that could be readily used in the model. For example, prices for Canadian hogs were quoted on slaughtered dressed carcass weights of 100 pounds. United States prices were quoted as live hogs. To convert the United States prices to their Canadian equivalent, a conversion factor of .78 was used. A further adjustment was made to account for the exchange rate differential between the two countries. The conversions were done as follows: (US price / .78) x exchange rate.

Canadian prices were not reported on the basis of East and West. To derive a West price, a simple weighted average procedure was followed using price and hog volumes from the three main producing provinces of the West -- Alberta, Saskatchewan and Manitoba. The Ontario price was used to represent Eastern prices. While it would have been more effective to include Quebec prices in the Eastern price, these prices are not reported. However, Quebec packers do base their prices on Ontario prices. The Maritime region represents a negligible influence on the Eastern hog market.

Once the variables were specified in an appropriate form, the VAR modelling techniques described in the previous sections were carried out. A lag length of three was deemed to be the most appropriate one. Impulse response analysis was then applied to determine if the increase in Canadian live hog exports did exert a significant impact on the US prices. Decomposition of variance was used to analyze the effect of the countervailing duty on pricing efficiency in the hog markets. A description of these procedures as applied to the North American hog prices, and the results of the analysis, are presented in Chapter VI.

# VI. RESULTS AND INTERPRETATION OF EMPIRICAL ANALYSIS

## A. INTRODUCTION

The preceding two chapters have presented the argument for analyzing pricing efficiency within VAR models, and a description of the methodology employed to test the study hypotheses. Chapter VI contains the results and interpretation of the empirical analysis.

The initial step involves a graphical analysis of the prices and the differentials between the three markets. This step is important in the empirical analysis as a means of identifying problem areas within the data set. It is also very useful for making some preliminary inferences about the price relationships.

The results and interpretation of the graphical analysis step is presented first, followed by that of the VAR analysis.

## B. PRICE DIFFERENTIALS IN HOG MARKETS

Discrepancies in the prices paid to hog producers in separate market areas, often considerably wider than the costs of transferring pork between regions, have long been of concern to producers. While it is not the intent of the present research to analyze in-depth the interregional market differentials, a perusal of these movements will be useful in identifying general trends and expected relationships between prices.

Trade patterns reflect intraregional supply and demand conditions and transfer costs among regions. Once patterns of trade are established, price differences among regions should reflect transfer costs from exporting to importing regions. However, patterns of trade do not necessarily remain stable over time. Changes in areas of

concentration of production and consumption may cause price differences between regions to change.

Several components have been identified as influencing price differentials:

1. Transportation and other transfer costs;
2. Local supply and demand conditions;
3. Non-economic considerations such as political factors;
4. Competitive structure of packing and retailing sectors;
5. Regional differences in the costs of hog production and processing; and
6. Seasonal factors.[102]

These factors are interrelated, and interact to produce a certain price differential for hogs between the various markets.

Figure VI-1 depicts the trends that have occurred in the three price regions (Western Canada, Eastern Canada, and the US-7 average) over the period 1982 to 1986. The three prices have followed a similar pattern over time. The price movements in the three markets do not infer any cyclical patterns, although the short timespan (five years) involved in the analysis may account for this anomaly.

A close relationship between the two Canadian price series is especially evident. It would also seem that the spread between the US price and the Canadian ones widened in early 1984. Price spreads between the three market areas will be studied more closely in the following sections.

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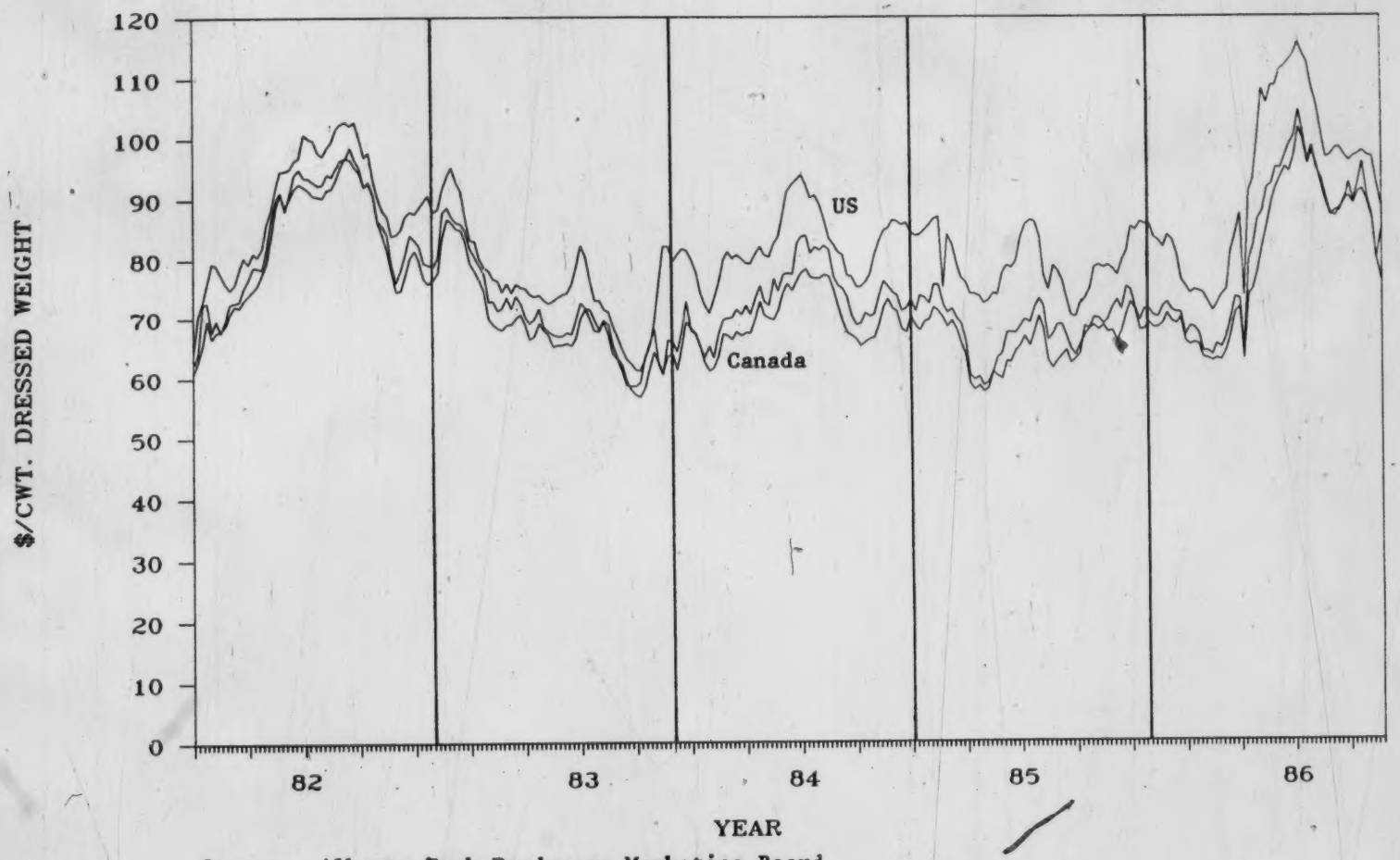
[102] Canadian Pork Council. "Spatial Price Differences for Hogs in Canada." Ottawa, Ontario. March 1979. p. 23.

Figure VI.1 Slaughter Hog Prices In Canada And The US, 1982-1986




Source: Alberta Pork Producers Marketing Board.

W. Canada-E. Canada Price Spreads

Figure VI-2 illustrates the price differential between Western Canada and Eastern Canada over the period 1982 to 1986. In most periods, the differential existed in favour of the East. In 1982 and 1983, the difference between the two markets fluctuated around a mean of approximately $2.00 per hundredweight. Fall of 1983 saw the spread move to $2.00 in the West's advantage. From 1984 to 1986, the spread widened somewhat, averaging between $2.00 and $4.00.

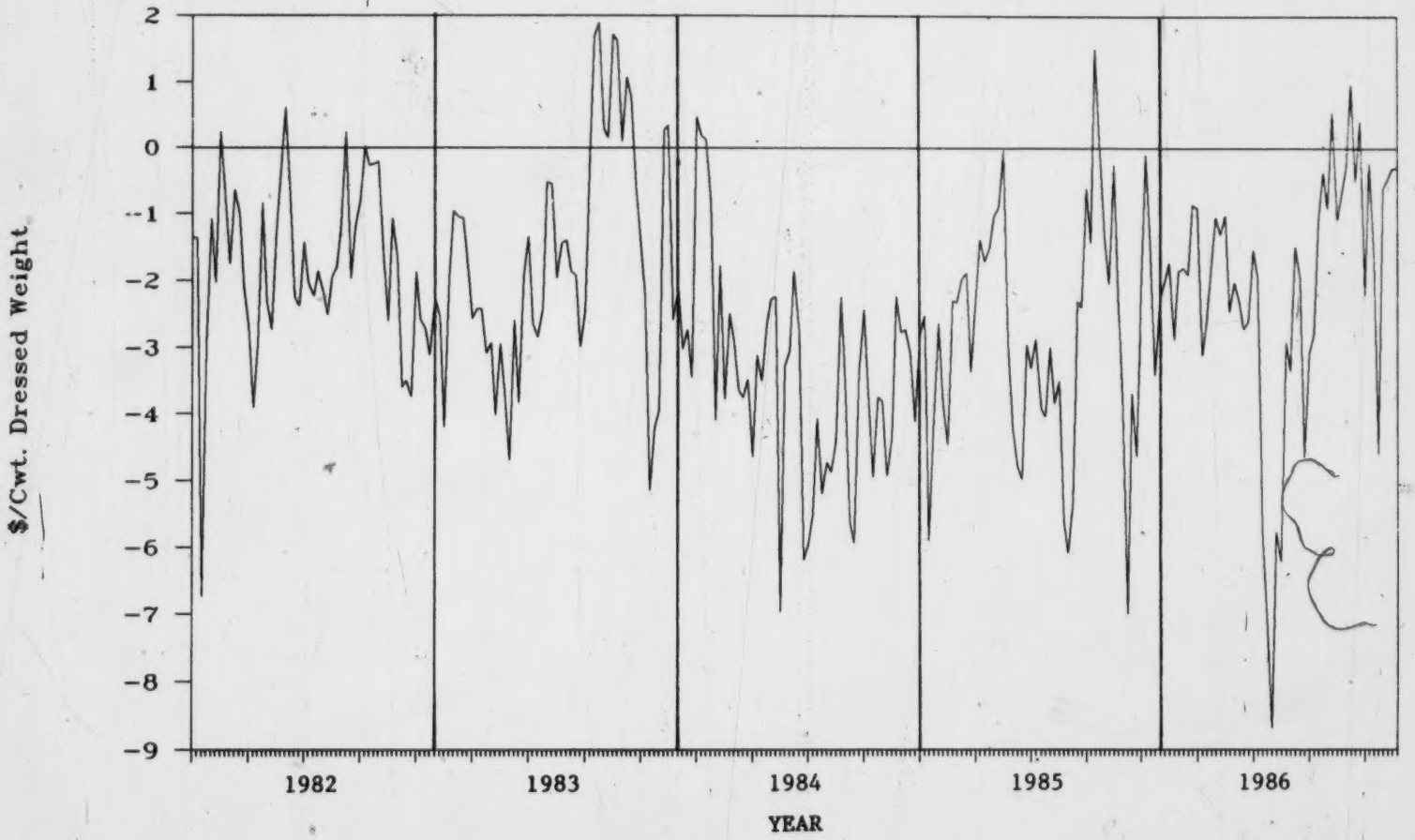
There was also considerable variation in this time period. The East realized an all-time high of $9.00 in June of 1986, after which the spread moved to $1.00 in favour of the West. All cases where the spread moved noticeably in favour of the West coincided with the Fall-Winter seasons.

Overall, with a few aberrations, the price spread between Western Canada and Eastern Canada has been in favour of the East, ranging from $2.00 to $4.00. There does not appear to be any noticeable narrowing of the gap over the years studied. There has been some widening of the spread after 1983.

Western Canada-US Price Spreads

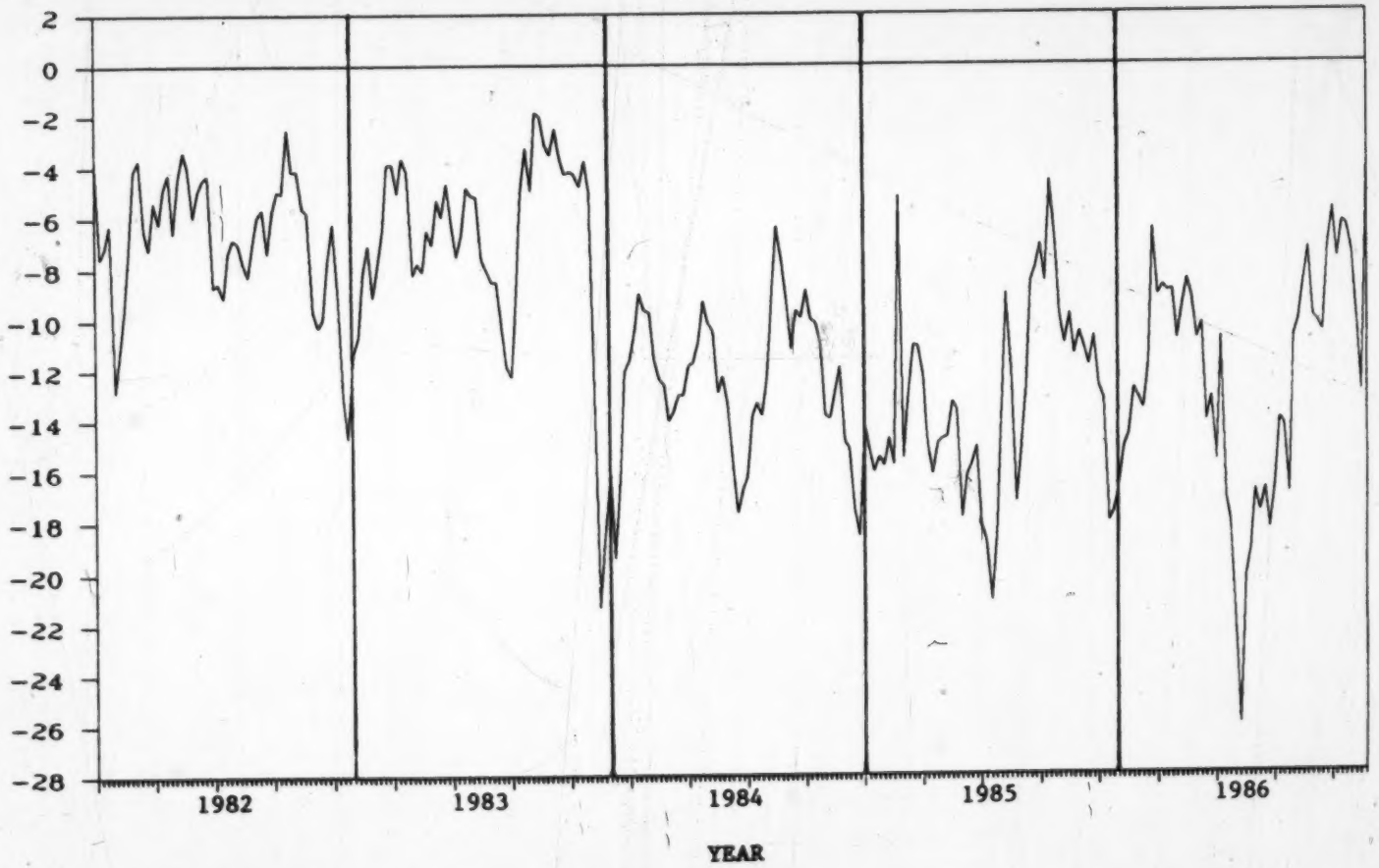
The price differentials between Western Canada and the US markets are shown in Figure VI-3. The most noticeable feature of this relationship is the persistent dominance of the US market in maintaining a sizeable spread over the Canadian market. The spread has ranged between $2.00 and $25.00 in the US' favour. In 1982 and 1983, the differential fluctuated around a mean of almost $7.00, with a range of $2.00 to $22.00. As was the case with the Western Canada-Eastern Canada relationship, the spread

Figure VI.2 Hog Price Differentials, 1982-1986. W. Canada Minus E. Canada




Source: Alberta Pork Producers Marketing Board.

Figure VI.3 Hog Price Differentials, 1982-1986. W. Canada Minus US-7




Source: Alberta Pork Producers Marketing Board.

widened from 1984 onward. Over this period, the mean fluctuated around $14.00 -- double that of the previous period.

### Eastern Canada-US Price Spreads

The East-US price difference displayed similar behaviour as compared to the West-US spread over the study period (Figure VI-4). During 1982 and 1983, the spread fluctuated around a mean of approximately $4.00. The price difference closed to almost $1.00 in favour of the East in late 1983, and then fell to an alltime low of $22.00 (in favour of the US) immediately thereafter. The remainder of the period saw a widening of the spread, averaging approximately $10.00. The preceding discussion regarding price differentials between the three study markets has provided insight into general price trends and movements, and has allowed inferences to be made regarding the market relationships. However, in order to make conclusive statements regarding these relationships, further analysis is required. The remainder of this chapter will present the results of the VAR analysis, along with conclusions regarding market behaviour over the study period.

## C. VAR MODELS

### Model Estimation

To analyze the pricing relationships in the North American hog markets, two nine-variable VAR models were estimated. Model I corresponded to the pre-countervailing duty period (January 1982 to April 1985), and Model II covered the post-countervailing duty period (April 1985 to December 1986). All variables were evaluated in natural logarithms, and a time

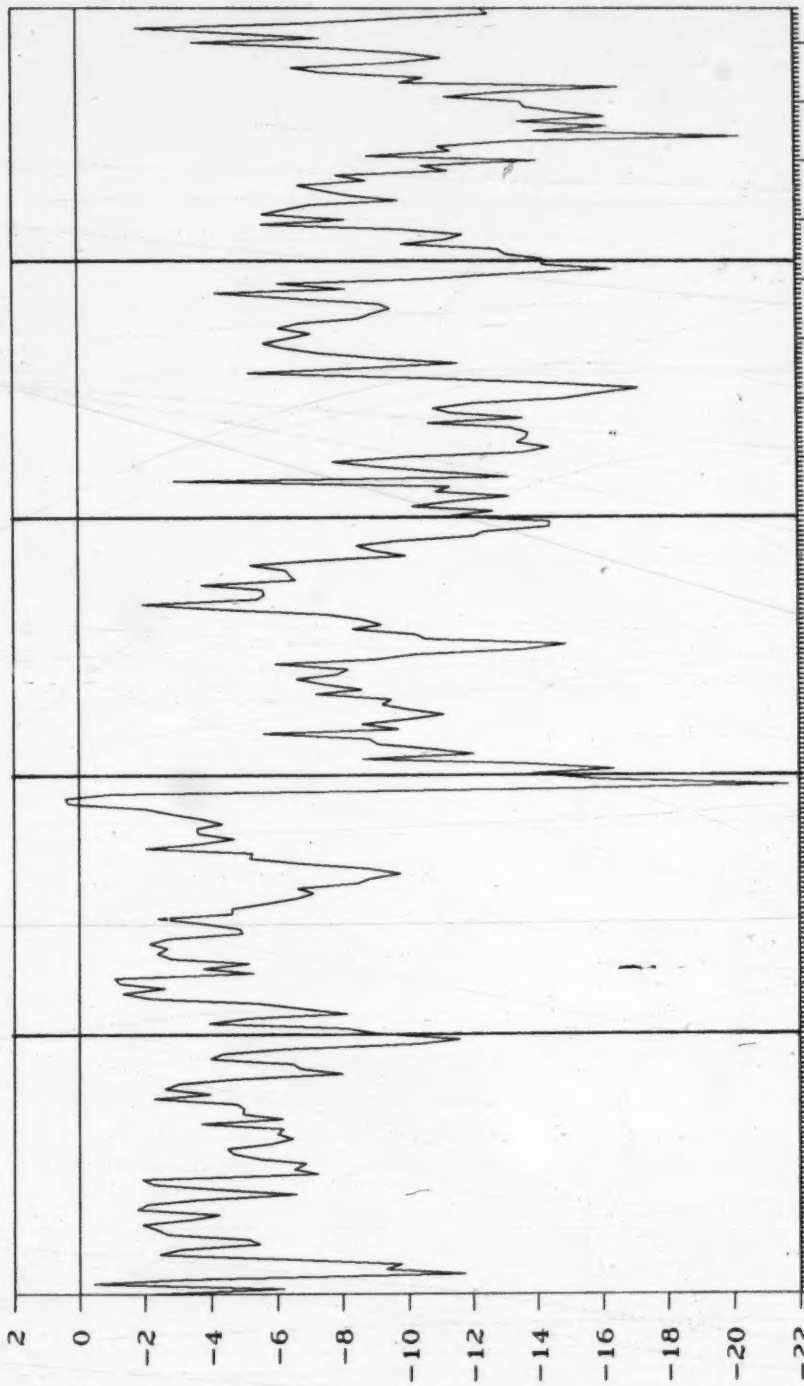



Figure VI.4 Hog Price Differentials, 1982-1986. E. Canada Minus US-7

Source: Alberta Pork Producers Marketing Board.

trend and constant were included to correct for non-stationarity in the data. The data set derived was thus represented by a stationary stochastic process. The price series were left in nominal terms, because, according to Orden, "constructing deflated values prior to estimation moves the analysis away from variables that are directly observable. One result is to entangle the dynamics of price-level effects with the effects of other variables."[103]

The first stage of the analysis involved selecting an appropriate lag length for the (endogenous) explanatory variables in each of the models. Recall from Chapter V that the choice of lag structure in a VAR implies that lags from any longer period do not add information to the model and have parameter values of zero. The importance of this procedure can be seen in that longer lag lengths increase the number of estimated parameters, reduce degrees of freedom, and increase data requirements.

The choice of lag-length was done on a system-wide basis (i.e. the complete model was tested, rather than individual equations or variables) using Sim's likelihood ratio test.[104] The results are reported in Table VI-1. It can be seen that the appropriate lag length for both models is three. These results agree with a priori expectations; one would expect that the effects of a change in the system (for example, a price increase) would be felt throughout the system within three weeks.

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[103]D. Orden. "Money and Agriculture: The Dynamics of Money-Financial Market - Agricultural Trade Linkages," Agricultural Economics Research. Volume 38, Summer 1986. pp. 14-28.

[104]All computations were done using the computer package "RATS" (Regression Analysis of Time Series) by Doan and Litterman.

Table VI.1 Likelihood Ratio Test To Determine Lag Length [1]

| | | |
|---|---|---|
| **Model I: 1982 - April 1985** | | |
| 2 versus 3 lags | $\chi^2(81) = 115.4$ | Reject 2 |
| 3 versus 4 lags | $\chi^2(81) = 97.48$ | Accept 3 |
| **Model II: April 1985-1986** | | |
| 2 versus 3 lags | $\chi^2(81) = 113.0$ | Reject 2 |
| 3 versus 4 lags | $\chi^2(81) = 96.5$ | Accept 3 |

Source: University of Alberta, Department of Rural Economy - August 1987.

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[1] Critical point equals 108 at 5 percent significance level.

A vector autoregression was then estimated on the nine-variable system by applying Ordinary Least Squares regression to each equation. Each variable was regressed on lagged values of itself and on lagged values of each of the remaining variables.

The parameter estimates from the regressions are not reported here, because, as discussed in Chapter V, interpretation of the AR coefficients in a VAR is of limited usefulness. The innovation accounting analysis instead allows the researcher to examine the dynamic relationships in the model.

The R-squares and standard deviations of errors associated with the autoregressive equations are shown in Table VI-2. The high R-square values for the price equations in both models indicate that the regressions likely explain a large percentage of the variation in these series. The low R-square values for the pork exports and imports equations suggest that there are other significant influences on these variables that have been omitted from the system. These factors could include the exchange rate, retail pork prices, prices of competing meats (beef and chicken), etc.

Table VI-3 reports the results of the Ljung-Box Q-test for serial correlation. Recall that temporal interdependence of successive values of a random variable u is an important assumption of Ordinary Least Squares. If the value of u in any particular period is correlated with its own preceding value (or values) (i.e. covariances do not equal zero), then autocorrelation is present. Consequences of autocorrelation include affected parameter estimates, underestimation of the variance of the random term u, and inefficient predictions based on OLS estimates. Table VI-3 shows that all estimated Q-values fall below the critical

Table VI.2 Measure Of Fit And Standard Deviation Of Errors- Autoregressive Equations

| Dependent Variable: | R-Square I | R-Square II | Standard Deviation of Errors I | Standard Deviation of Errors II |
|---|---|---|---|---|
| West Hog Exports | .86 | .64 | .3663 | .5719 |
| East Hog Exports | .78 | .66 | 1.3162 | 1.7262 |
| West Price | .98 | .98 | .0206 | .0302 |
| U.S.-7 Price | .95 | .96 | .0262 | .0357 |
| East Price | .95 | .97 | .0285 | .0322 |
| West Pork Exports | .59 | .34 | .5445 | .3142 |
| East Pork Exports | .20 | .36 | .5096 | .3190 |
| West Pork Imports | .49 | .54 | .9865 | 1.2936 |
| East Pork Imports | .34 | .44 | 1.0379 | 1.8386 |

Source: University of Alberta, Department of Rural Economy - August 1987.

Table VI.3 Ljung-Box Q Test For Serial Correlation

| Dependent Variable: | Model I Q(36) [2] | Model II Q(27) [3] |
|---|---|---|
| West Hog Exports | 49.5 | 18.9 |
| East Hog Exports | 50.4 | 22.5 |
| West Price | 28.9 | 24.4 |
| U.S.-7 Price | 17.5 | 12.3 |
| East Price | 23.4 | 34.6 |
| West Pork Exports | 29.5 | 29.8 |
| East Pork Exports | 40.8 | 31.1 |
| West Pork Imports | 27.7 | 9.7 |
| East Pork Imports | 28.4 | 11.9 |

Source: University of Alberta, Department of Rural Economy - August 1987.

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[2] Critical point equals 51 at 5 percent significance level.

[3] Critical point equals 40.1 at 5 percent significance level.

values, indicating that no autocorrelation is present.

The results of separate F-tests for the null hypothesis that coefficients on lags associated with a particular variable are zero are reported for the two models in Tables VI-4 and VI-5. Elements in the table represent the significance level of the corresponding F-statistic. These report the probability of observing the computed (but not reported) value of F under the assumption that the null hypothesis is true. These tests are interpreted as within-sample causality tests. Cases in which evidence is present for rejecting the null hypothesis at the 95-percent confidence level are underlined.

The F-tests reported in Tables VI-4 and VI-5 for the price equations have several implications. First, there is evidence of considerable feedback between most of the price series. In the West price equation, in Model I, all three lagged price series are significant, while in Model II, only lagged West prices and lagged US prices indicate significance. Lagged US prices are significant in their own equation in both models, while neither West nor East prices are. At the 90-percent confidence level, however, lags of East prices are significant in Model I. The results from the East price equation indicate that lagged US and East prices are significant in Model I, while only lagged East prices are significant in Model II.

In general, the evidence from the F-tests suggests that West prices are led by both US and East prices; US prices are independent of the other prices; and East prices are led by US prices but not West prices. The significance of US prices in the East price equation in Model I but not Model II would suggest that the countervailing duty has had some impact on pricing efficiency in that market. It should also be

Table VI.4 F-Test for Significance Of Lags Of Each Variable, Model I

| | Lagged Variables | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WHX | EHX | WP | USP | EP | WPX | EPX | WPI | EPI |
| Dependent Variable: | | | | | | | | | |
| WHX | 0 | .586 | .327 | .125 | .206 | .250 | .553 | .233 | .194 |
| EHX | .253 | 0 | .143 | .917 | .133 | .009 | .021 | .250 | .440 |
| WP | .108 | .726 | 0 | 0 | .006 | .639 | .327 | .126 | .157 |
| USP | .961 | .750 | .218 | 0 | .106 | .624 | .451 | .256 | .178 |
| EP | .473 | .676 | .885 | 0 | 0 | .265 | .109 | .007 | .010 |
| WPX | .135 | .934 | .401 | .235 | .568 | 0 | .001 | .494 | .740 |
| EPX | .049 | .935 | .220 | .133 | .753 | .050 | .020 | .420 | .669 |
| WPI | .831 | .220 | .359 | .039 | .518 | .340 | .385 | .010 | .002 |
| EPI | .751 | .305 | .706 | .041 | .654 | .338 | .444 | .691 | 0 |

Underlined values indicate evidence for rejecting null hypothesis (that coefficients on lags are zero) at the 95-percent confidence level.

Source: University of Alberta, Department of Rural Economy - August 1987.

Table VI.5 F-Test For Significance Of Lags Of Each Variable, Model II

| | Lagged Variables | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | WHX | EHX | WP | USP | EP | WPX | EPX | WPI | EPI |
| Dependent Variable: | | | | | | | | | |
| WHX | .030 | .168 | .006 | .379 | .351 | .348 | .667 | .799 | .491 |
| EHX | .213 | .127 | .759 | .047 | .398 | .095 | .134 | .315 | .574 |
| WP | .217 | .012 | .008 | .05 | .414 | .947 | .963 | .925 | .119 |
| USP | .202 | .398 | .320 | 0 | .608 | .784 | .714 | .828 | .661 |
| EP | .050 | .239 | .612 | .05 | .005 | .766 | .811 | .916 | .884 |
| WPX | .262 | .536 | .316 | .541 | .967 | .488 | .816 | .898 | .842 |
| EPX | .255 | .518 | .358 | .647 | .953 | .190 | .523 | .845 | .766 |
| WPI | .180 | .946 | .155 | .050 | .050 | .420 | .648 | .366 | .036 |
| EPI | .118 | .514 | .164 | .008 | .004 | .699 | .778 | .009 | .009 |

Underlined values indicate evidence for rejecting null hypothesis (that coefficients on lags are zero) at the 95-percent confidence level.

Source: University of Alberta, Department of Rural Economy - August 1987.

noted here that hog exports were not significant in the US price equation in either model.

While the F-tests can imply that a Granger-type causal relationship may exist, they provide little evidence as to the dynamic properties of the system. As Sims has noted, estimated VARs "are difficult to describe succinctly"; he goes on to argue that the moving average representation offers a far more comprehensible picture.[105] The analysis must be carried further to apply the innovation accounting techniques to the estimated VARs. Results are reported in the subsequent section.

Innovation Accounting Analysis

The final step in the VAR modelling is applying the innovation accounting techniques to the system. This is accomplished by transforming the autoregressive equations into their moving average representation. To transform the system, the innovations must first be orthogonalized. This triangularization procedure is necessary to account for contemporaneous correlation between the residuals. Orthogonalized innovations are desirable because they are uncorrelated both across time and across equations. The principal advantage of orthogonalized innovations over non-orthogonalized ones is that it can be misleading to refer to a shock to a single variable in isolation when historically it has always moved together with several other variables (as is the case with North American hog prices).

The nine-variable VAR was triangularized in order from highest to lowest as follows: East hog exports, West hog exports, East pork

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[105] C. A. Sims. op. cit. p. 32.

exports, West pork exports, East pork imports, West pork imports, US price, East price and West price. Live hog and pork exports and imports were placed before prices because, according to Bessler's work on the US hog market, price is more likely to adjust to quantity of hogs than vice versa.[106] Exports were ordered before imports because it is believed that prices on the North American (or world) market most likely influence the total value of agricultural exports more than they do agricultural imports.[107] Finally, hog exports were placed above pork exports because it was felt that in the short term, due to storage stocks of processors, the pork variables could respond more expediently to changes in the system. In the very short run, processors are likely to be able to come forth with greater quantities (or, conversely, hold back quantities) of the product, than are producers able to alter immediate supplies of live hogs.

Turning to the innovation accounting analysis, the decomposition of variance for forecasts up to 33 weeks ahead are reported in Tables VI-6 and VI-7. Only the series of relevance in the analysis -- prices and live hogs exports -- are included. Keep in mind when studying the tables, however, that four other variables were included in the model and accounted for a small portion of the forecast error variance.

The statistics reported in the two tables measure the proportion of the error variance in each variable that can be attributed to shocks (or "innovations") in the variables. Evidence of dynamic relationships between the economic series can then be inferred.

Implications of the F-tests, as reported in an earlier section, are generally confirmed by the decomposition of variance results.

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[106]D. A. Bessler. op. cit. p. 110.
[107]T. Sanni. op. cit. p. 70.

Table VI.6 Variance Decomposition Of Prediction Errors, Model I

| Variable | Week | Standard Error | Proportion of Error Attributed to Shock In: USP | EP | WP | WHX | EHX |
|---|---|---|---|---|---|---|---|
| USP | 1 | .024 | 97.1 | 0 | 0 | 2.3 | .1 |
| | 5 | .065 | 78.8 | 7.9 | 2.7 | 1.4 | .4 |
| | 9 | .086 | 64.5 | 9.3 | 8.9 | .8 | .9 |
| | 13 | .096 | 59.9 | 9.9 | 10.7 | .7 | 1.3 |
| | 17 | .100 | 58.3 | 10.2 | 11.0 | .6 | 1.5 |
| | 21 | .102 | 57.6 | 10.5 | 11.0 | .6 | 1.5 |
| | 25 | .104 | 57.1 | 10.5 | 11.1 | .6 | 1.6 |
| | 29 | .105 | 56.9 | 10.6 | 11.1 | .6 | 1.6 |
| | 33 | .106 | 56.7 | 10.6 | 11.1 | .6 | 1.6 |
| EP | 1 | .026 | 14.1 | 74.5 | 0 | | |
| | 5 | .059 | 44.9 | 43.3 | 1.4 | | |
| | 9 | .079 | 48.4 | 31.9 | 5.9 | | |
| | 13 | .080 | 47.6 | 27.3 | 9.2 | | |
| | 17 | .098 | 47.0 | 25.5 | 10.3 | | |
| | 21 | .101 | 46.7 | 24.8 | 10.6 | | |
| | 25 | .103 | 46.7 | 24.4 | 10.7 | | |
| | 29 | .105 | 46.6 | 24.1 | 10.8 | | |
| | 33 | .106 | 46.5 | 23.9 | 10.8 | | |
| WP | 1 | .019 | 10.9 | 47.9 | 27.5 | | |
| | 5 | .056 | 46.6 | 37.7 | 6.4 | | |
| | 9 | .077 | 49.0 | 28.8 | 8.4 | | |
| | 13 | .089 | 47.5 | 24.9 | 11.4 | | |
| | 17 | .095 | 46.7 | 23.5 | 12.2 | | |
| | 21 | .099 | 46.4 | 23.0 | 12.4 | | |
| | 25 | .101 | 46.4 | 22.7 | 12.4 | | |
| | 29 | .102 | 46.3 | 22.5 | 12.4 | | |
| | 33 | .103 | 46.3 | 22.4 | 12.4 | | |

Source: University of Alberta, Department of Rural Economy - August 1987.

Table VI.7 Variance Decomposition Of Prediction Errors, Model II

| Variable | Week | Standard Error | Proportion of Error Attributed to Shocks In: USP | EP | WP | WHX | EHX |
|---|---|---|---|---|---|---|---|
| USP | 1 | .029 | 84.2 | 0 | 0 | .6 | 13.6 |
| | 5 | .055 | 66.9 | 0 | 3.8 | 3.5 | 9.2 |
| | 9 | .060 | 58.2 | 1.3 | 4.9 | 3.0 | 8.0 |
| | 13 | .061 | 57.1 | 1.6 | 5.7 | 3.1 | 7.9 |
| | 17 | .061 | 56.6 | 1.6 | 5.8 | 3.3 | 7.8 |
| | 21 | .061 | 56.3 | 1.7 | 6.0 | 3.3 | 7.7 |
| | 25 | .061 | 56.3 | 1.7 | 6.0 | 3.3 | 7.7 |
| | 29 | .061 | 56.2 | 1.7 | 6.1 | 3.3 | 7.7 |
| | 33 | .061 | 56.2 | 1.7 | 6.1 | 3.3 | 7.7 |
| EP | 1 | .026 | 50.7 | 41.9 | 0 | | |
| | 5 | .044 | 54.3 | 23.8 | 3.7 | | |
| | 9 | .048 | 47.7 | 22.0 | 4.0 | | |
| | 13 | .048 | 46.4 | 21.5 | 5.7 | | |
| | 17 | .049 | 46.2 | 21.3 | 5.8 | | |
| | 21 | .049 | 46.0 | 21.2 | 6.0 | | |
| | 25 | .049 | 46.0 | 21.1 | 6.1 | | |
| | 29 | .049 | 46.0 | 21.1 | 6.1 | | |
| | 33 | .049 | 46.0 | 21.1 | 6.1 | | |
| WP | 1 | .025 | 38.5 | 20.7 | 37.0 | | |
| | 5 | .039 | 47.9 | 14.0 | 18.9 | | |
| | 9 | .044 | 41.0 | 14.4 | 15.0 | | |
| | 13 | .045 | 40.5 | 14.2 | 15.7 | | |
| | 17 | .045 | 40.1 | 14.1 | 15.8 | | |
| | 21 | .046 | 40.0 | 14.0 | 16.0 | | |
| | 25 | .046 | 40.0 | 14.0 | 16.0 | | |
| | 29 | .046 | 40.0 | 14.0 | 16.0 | | |
| | 33 | .046 | 40.0 | 14.0 | 16.0 | | |

Source: University of Alberta, Department of Rural Economy - August 1987.

Considerable feedback between the three price series is evident. US prices appear to have the greatest influence on the three series. The US price is nearly exogenous in the very short-run, as over 97 percent of its forecast error variance is accounted for by its own innovations at a one-week horizon (Model I). In Model II, its exogeneity drops somewhat, to 84.2 percent. At further horizons, in Model I, East and West prices also explain a significant portion of forecast error variance. The series remains largely explained by its own innovations in both models, however.

Forecast error variance in the East price series is explained primarily by innovations in all three series in Model I, and by the US and East prices in Model II. The US prices account for 46 to 54 percent of the variance. The West price series explains a somewhat smaller portion of the variance in Model II as compared to Model I.

The tables show that the greatest influence on the West prices is attributed to innovations in the US price series. In both models, US prices account for between 40 and 50 percent of West price forecast error variance. Own-shocks appear to explain a higher proportion of the variance in the post-countervailing duty period. The influence of the East price is reduced noticeably in Model II, while the influence of the US price drops by a smaller margin.

The results also indicate that the live hog exports do not appear to account for much of the error variance in the US prices, in either model.

Tables VI-6 and VI-7 also contain the forecast standard errors at the different forecast horizons. As the horizons grow, the errors also increase, as one would expect. Sims states that, "For a stationary

process, forecast standard error tends to some upper bound as the horizon increases."[108] The tables show that the standard errors meet this criteria, indicating a stationary system. Forecast standard errors for the remaining six series in the VAR models were also checked, and they too met the stationarity requirement.

Table VI-8 contains further evidence pertaining to the relationships between North American hog prices. The table reports changes in forecast error variances before and after imposition of the countervailing duty. The results indicate that the influence of the US prices on itself, and on the Canadian prices, diminished in the post-duty period. The drop was felt most by the West prices. The greatest impact seems to have been in the intermediate term -- horizons of nine and 13.

The influence of the East price also decreased on all three price series after imposition of the trade barrier. Own-shocks in the West price increased, while their influence on the other two series decreased.

The influence of the live hog exports on US prices declined after the duty was imposed, at a time when export quantities were dropping.

The sensitivity of the variance decompositions to the ordering of the variables was then addressed. By inspecting the contemporaneous correlations of the residuals in each model it was possible to identify variable combinations that could pose a problem in the analysis. Tables VI-9 and VI-10 present the residual cross-correlations for the two models. The pairs displaying high cross-correlation were: East and West prices, East and West pork exports, and East and West pork imports in

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[108]C. A. Sims. op. cit. p. 36.

Table VI.8 Changes In Variance Decomposition Between Model I And Model II

| Variable | Week | Proportion of Error Attributed to Shocks In: USP | EP | WP | WHX | EHX |
|---|---|---|---|---|---|---|
| USP | 1 | -12.9 | 0 | 0 | -1.7 | 13.5 |
| | 5 | -11.9 | -7.9 | 1.1 | 2.4 | 8.8 |
| | 9 | -6.3 | -8.0 | -4.0 | 4.1 | 7.1 |
| | 13 | -2.8 | -8.3 | -5.0 | 5.0 | 6.6 |
| | 17 | -1.7 | -8.6 | -5.2 | 5.2 | 6.3 |
| | 21 | -1.3 | -8.8 | -5.0 | 5.4 | 6.2 |
| | 25 | -0.8 | -8.8 | -5.1 | 5.4 | 6.1 |
| | 29 | -0.7 | -8.9 | -5.0 | 5.5 | 6.1 |
| | 33 | -0.5 | -8.9 | -5.0 | 5.5 | 6.1 |
| EP | 1 | 36.6 | -32.6 | 0 | | |
| | 5 | 9.4 | -19.5 | 2.3 | | |
| | 9 | -0.7 | -9.9 | -1.9 | | |
| | 13 | -1.2 | -5.8 | -3.5 | | |
| | 17 | -0.8 | -4.2 | -4.5 | | |
| | 21 | -0.7 | -3.6 | -4.6 | | |
| | 25 | -0.7 | -3.3 | -4.6 | | |
| | 29 | -0.6 | -3.0 | -4.7 | | |
| | 33 | -0.5 | -2.8 | -4.7 | | |
| WP | 1 | 27.6 | -27.2 | 9.5 | | |
| | 5 | 1.3 | -23.7 | 12.5 | | |
| | 9 | -8.0 | -14.4 | 6.6 | | |
| | 13 | -7.0 | -10.7 | 4.3 | | |
| | 17 | -6.6 | -9.4 | 3.6 | | |
| | 21 | -6.4 | -9.0 | 3.6 | | |
| | 25 | -6.4 | -8.7 | 3.6 | | |
| | 29 | -6.3 | -8.5 | 3.6 | | |
| | 33 | -6.3 | -8.4 | 3.6 | | |

Source: University of Alberta, Department of Rural Economy - August 1987.

Table VI.9 Residual Cross Correlations, Model I

| | WHX | EHX | WP | USP | EP | WPX | EPX | WPI | EPI |
|---|---|---|---|---|---|---|---|---|---|
| WHX | 1.0 | | | | | | | | |
| EHX | .208 | 1.0 | | | | | | | |
| WP | -.306 | -.166 | 1.0 | | | | | | |
| USP | -.139 | .038 | .357 | 1.0 | | | | | |
| EP | -.189 | -.242 | .834 | .380 | 1.0 | | | | |
| WPX | -.082 | -.020 | .132 | .044 | .156 | 1.0 | | | |
| EPX | -.063 | -.047 | .116 | .039 | .144 | .968 | 1.0 | | |
| WPI | .099 | -.042 | .091 | -.074 | .098 | -.030 | 0 | 1.0 | |
| EPI | .092 | -.025 | .056 | -.055 | .072 | .010 | .011 | .881 | 1.0 |

Source: University of Alberta, Department of Rural Economy - August 1987.

Table VI.10 Residual Cross Correlations, Model II

| | WHX | EHX | WP | USP | EP | WPX | EPX | WPI | EPI |
|---|---|---|---|---|---|---|---|---|---|
| WHX | 1.0 | | | | | | | | |
| EHX | .368 | 1.0 | | | | | | | |
| WP | -.109 | -.067 | 1.0 | | | | | | |
| USP | .210 | .368 | .555 | 1.0 | | | | | |
| EP | -.045 | -.159 | .765 | .616 | 1.0 | | | | |
| WPX | .160 | -.208 | -.133 | -.157 | -.038 | 1.0 | | | |
| EPX | .159 | -.208 | -.137 | -.163 | -.062 | .992 | 1.0 | | |
| WPI | .032 | .248 | -.113 | .055 | -.055 | .234 | .243 | 1.0 | |
| EPI | .014 | .227 | -.116 | .035 | -.051 | .168 | .167 | .879 | 1.0 |

Source: University of Alberta, Department of Rural Economy - August 1987.

Model I; US and West prices, East and West prices, East and US prices, East and West pork exports, and East and West pork imports in Model II. The variance decompositions were then recomputed, switching the order of the variables that were highly correlated. In none of the cases reported above did this appear to be a problem.

The impulse responses depicting the influence of shocks in live hog exports on the US prices are shown in Table VI-11. The results indicate that the shocks caused little change in the US prices over the pre-countervailing duty period. These findings are in agreement with those of the decomposition of variance results.

## D. SUMMARY

The empirical work in this chapter has had two objectives. First, the impact of the countervailing duty on the pricing relationships in the North American hog markets were assessed, using graphical illustrations of the price differentials and the innovation accounting techniques of VAR modelling. The second objective was to study the impact of live hog exports on the US prices, again employing the innovation accounting techniques. Conclusions and recommendations stemming from the empirical results will be presented in the final chapter.

Table VI.11 Responses To One Standard Deviation Shock In Live Hog Exports On US Prices

| Week | West Hog Exports | East Hog Exports |
|---|---|---|
| 1 | -.0004 | .0009 |
| 5 | -.0018 | -.0029 |
| 9 | -.0002 | -.0039 |
| 13 | -.0005 | -.0029 |
| 17 | -.0004 | -.0023 |
| 21 | -.0003 | -.0018 |
| 25 | -.0003 | -.0014 |
| 29 | -.0003 | -.0011 |
| 33 | -.0003 | -.0009 |

Source: University of Alberta, Department of Rural Economy - August 1987.

# VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## A. REVIEW OF RESEARCH OBJECTIVES

The objectives of the study were twofold: 1) to evaluate the effect of the Canadian swine imports into US midwest markets on those prices, and 2) to assess the effect of the countervailing duty on pricing efficiency in the Canadian hog markets. These objectives were established in view of the concern expressed by the Canadian hog industry over the action taken by its US counterpart in erecting the trade barrier. The objectives were also set out in light of the concerns of the Canadian population as a whole regarding the progress in the "freer" trade talks and the protectionist mood taking hold south of the border. It is widely recognized that the Canadian livestock industry as it now stands relies heavily on export markets. Gaining and maintaining access to the large US market is of key concern to the industry.

The study dealt largely with pricing relationships between the hog industries in the two countries. Recall that pricing efficiency refers to the "accuracy, rapidity and effectiveness with which market information is developed and disseminated." [109] Accurate and rapid information flow between markets that trade is an important prerequisite to efficient marketing. Information must be accurately and rapidly transmitted to market participants in order that prices fairly represent market conditions. If price differences exist after transfer costs are considered, arbitrage should occur to level the differential. Pricing efficiency is ultimately said to exist if prices reflect and coordinate the buying and selling activities of the farmers, marketing firms and

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[109] W. Williams and T. Stout. op. cit.

consumers.

An empirical methodology comprised of two components was used to evaluate the study hypotheses. The first step in the process was a graphical analysis, which was used to "view" the data and make inferences about the pricing relationships. The VAR analysis was the second step in the empirical testing. This step was necessary for making conclusive statements regarding the hypotheses.

The next two sections contain summaries of the graphical and VAR analyses.

## B. SUMMARY OF GRAPHICAL ANALYSIS

The graphical analysis consisted of two components: 1) a review of historical trends and patterns in the three price series, and 2) an assessment of price differentials between the three regions.

### Historical Price Movements

The three price series under study -- Western Canada, Eastern Canada and the US-7 average -- followed a very similar pattern over the course of the study. A close relationship was especially evident between the two Canadian price series. For the first half of 1982, the prices trended upward; from the second half of 1982 to 1984, they moved downward; from 1984 to 1986 they fluctuated around the same level; and in the second quarter of 1986 the three price series moved rapidly upward. The spread between the US price and the Canadian price series appeared to widen in 1984. This relationship appeared to remain fairly constant until the end of the study period, although there was more variability in 1986 than in the previous two year.

The graph did not reveal any definite cyclical patterns, although this may be a function of the short timeframe (five years) involved in the analysis. A longer period might have allowed some cyclical patterns to appear. Overall, the graph did not reveal any major aberrations in the price movements between 1982 and 1986.

Price Differentials

1. Western Canada Minus Eastern Canada -From 1982 to 1986, the price differential between Western Canada and Eastern Canada existed in favour of the latter in all but a few periods. The differential fluctuated between $0 and $9.00 in favour of the East. It reversed to the West's favour in the third quarters of 1983 and 1984 at $2.00, and then reverted to a traditional pattern in the final months of the study. The price differential appeared to move to the West's favour during the fall and winter months. Overall, however, a trend toward narrowing of the spread between the two regions was not evident.
2. Western Canada Minus US-7: The price differential between Western Canada and the US existed in the US' favour continually over the study period. For the first two years, the gap averaged approximately $7.00, with a range of $2.00 to $22.00. For the remainder of the period, after 1983, the differential averaged about $14.00.
3. Eastern Canada Minus US-7: The Eastern Canada-US price spread displayed similar behaviour to the Western Canada-US spread. From 1982 to 1983, the spread fluctuated around a mean of approximately $4.00 - $3.00 less than the Western Canada-US average spread. In the

latter part of 1983, the differential favoured Eastern Canada for a brief time. However, after 1983, the spread widened in the US' favour, averaging around $10.00.

4. As was the case in the review of historical price trends, cyclical patterns were not evident from the graphical analysis of price differentials.

C. SUMMARY OF VAR ANALYSIS

The VAR analysis was then conducted to test the study hypotheses in a more conclusive manner. The following section presents first a summary of technical results, and then a review of overall findings.

Technical Results

1. The likelihood ratio tests determined that a lag length of three weeks was most appropriate for the two models. These results infer that lags of any longer period would not add information to the model and would have parameter values of zero.
2. The three price equations in both models displayed high R-square values, suggesting that the regressions likely explained a large percentage of the variation in the series.
3. The Ljung-Box Q-tests indicated that both models were free of serial correlation.
4. The F-tests to examine the null hypothesis that coefficients on lags associated with a particular variable were zero had several implications for the pricing relationships. First, there was evidence of considerable feedback between most of the price series. In the West price equation, all three lagged prices were significant

in Model I, while West and US prices only were significant in Model II. In the US price equations, in both models, only the US price was significant. Neither of the Canadian prices were significant. In the East price equation, the US and East prices were significant in Model I but only East prices were significant in Model II.

Overall, the results of the F-tests suggested that: 1)West prices were led by both US and East prices; 2)East prices were led by US prices but not West prices; and 3)US prices were exogenous. The F-tests also indicated that Canadian hog exports were not significant in the US price equation in either

5. Decomposition of variance results generally confirmed the inferences made by the F-tests. Considerable interrelatedness between the price series was evident, particularly in Model I. US prices had the greatest influence on the three series. In the very short-run, the US price was almost completely exogenous, particularly in Model I. The US price series explained the majority of the variance in the East price in both models. The second greatest influence was the "own innovations," and West prices explained a small portion of the variance. The strongest influence on the West price was the US price series in Model I. The East price exerted the second largest influence in Model I, while in Model II both Canadian prices had a similar effect. The East price's influence was reduced noticeably in Model II. The decomposition of variance results also indicated that the Canadian swine exports did not account for much of the variance in the US prices, in either model.
6. The forecast standard errors of the two models tended to increase as the forecast horizon broadened, indicating that the system was

stationary.

7. A comparison of the forecast error variances between the two models provided further evidence that the effect of the US price on the two Canadian price series diminished after the countervailing duty. The drop was greatest on the Western Canada prices. The influence of the East price on all three series was also lessened.
8. Impulse response analysis further showed that the Canadian hog exports did not exert a statistically significant influence on the US prices during the pre-countervailing duty period.

D. CONCLUSIONS

Keeping in mind the limitations of the research as outlined in Chapter I, the analysis has led to the following conclusions:

1. Price movements in the three markets under study: Western Canada, Eastern Canada and the US-7 average follow very similar trends.
2. Price differentials widened after 1983.
3. Canadian live hog exports did not have a significant impact on the US prices in the pre-countervailing duty period.
4. The imposition of the countervailing duty had a negative impact on pricing efficiency in the Canadian hog markets. Feedback between the two Canadian markets also diminished after the duty was enforced.

The results are consistent with what one would expect, according to industrial organization theory. As Williams and Stout stated when listing several criteria for judging pricing efficiency: "Restrictions to entry and exit or barriers to trade are usually considered impediments to progress. Some exceptions are justified, however, as in

the case of plant and animal disease control."[110] The two authors continued: "Markets will have increased efficiency with more information than less, and all participants should be equally and uniformly informed."[111]

The results of the empirical analysis indicated a decline in feedback and greater isolation of the markets after the countervailing duty. Other factors that may have played a role in this process include: the currency exchange rate between the two countries, and the non-tariff (particularly health) regulations.

It is assumed that the price discovered in the slaughter hog markets in the US midwest states more closely resembles that of the perfectly competitive equilibrium norm. The numbers of participants in these markets (both producers and packers) are higher than that of the Canadian markets. In Western Canada, in particular, the hog slaughtering industry resembles an oligopsonistic structure.

A decline in feedback between the US markets and the Canadian markets would indicate the introduction of pricing inefficiencies into the markets. Recall that pricing efficiency is one of two pivotal components in market performance. Market performance refers to progress of an industry in developing new technology and satisfying consumer demands for new products, profits of the industry and macroeconomic goals of full employment or resource usage. A decline in pricing efficiency within a particular market would therefore be of concern to the industry. One should bear in mind, however, that a complete appraisal of market performance would include the other element of

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[110]Ibid.
[111]Ibid.

evaluation -operational efficiency.

The results of the VAR analysis indicated that a lag length of three weeks was appropriate. These findings imply that any changes that occur in the system, either on the supply side or the demand side, would be felt throughout the system within three weeks. This would suggest to policy-makers that policy changes would take up to three weeks to be felt. One would therefore want to build a lead time of three weeks into any policy formulation.

The findings of the research that the Canadian markets became more isolated after the countervailing duty also have implications for policy-makers. It would appear that three options would be available to counteract the negative impact of the countervailing duty on Canadian hog prices: 1) develop other export markets, such as Japan, 2) encourage decreased production, with the intent of serving only the domestic market, and 3) continue negotiations with the US to gain freer access to that market. The current "freer" trade talks with the US may result in some reduction of trade barriers between the two countries. Canada has at times exported large quantities of pork to the Japanese market. However, their move toward increased protectionism, and the competition from Danish exports, make this option difficult to achieve. Finally, the alternative of creating a supply-managed Canadian hog industry has been met with opposition in recent years by many livestock producers. The solution to the problem of the countervailing duty, then, would appear to be a complicated issue that will require an in-depth review in the months to come.

## E. RECOMMENDATIONS FOR FUTURE RESEARCH

1. It is recommended that further in-depth analysis of the price differentials between the three market areas be conducted, particularly with regard to the influence of seasonal factors on the spreads.
2. An analysis of the impact of the countervailing duty on pricing efficiency could be conducted using data up until the end of 1987. The availability of only 21 months of post-countervailing duty data is a limitation in the study.
3. Future research using the VAR technique may want to consider incorporating a Bayesian prior into the model. This is a relatively new approach to VAR modelling and indicates some promise for refining the technique.
4. A future study of hog markets may also want to consider using daily prices to capture even more of the fluctuations experienced in those markets.

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